COMPASSION in world farming **Food Business**

DRY SOWS

The business case for a cage-free transition

We are witnessing a global transition away from caged production for multiple farmed animal species, driven by increasing consumer demand, legislative reform and corporate policies. This document outlines the case for companies to commit to ending the use of sow stalls and implement sow stall-free sourcing. Business considerations, animal health and welfare, consumer and farmer attitudes, product quality, and environmental impact are considered.

Definitions of terms (EFSA, 2022)

'Sow': a female pig after the first farrowing.

'Gilt': a female pig after puberty and before farrowing, reared to replace sows in the breeding herd.

'Dry pregnant sow': also referred to as breeding sow, a sow from weaning her piglets to the perinatal period / farrowing.

'Sow stall': also referred to as 'gestation crate'. Individual housing in stalls, from service and the observation period, throughout gestation, to when the sow is moved to farrowing accommodation – usually one week prior to farrowing.

Throughout this document, **'sow stall free'** refers to the period from immediately after weaning (for sows, or upon entering service for gilts) to one week prior to farrowing and includes service and the observation period (confirmation of pregnancy). Sows are permitted to be confined for insemination for a maximum of 4 hours.

Dry pregnant sows and gilts, from entering service, throughout gestation until one week prior to farrowing, will be synonymously termed **'dry sows'**. Individual housing, sow stalls and gestation crates will be synonymously termed **'sow stalls'** or just '**stalls'**.

© Compassion in World Farming

CONTENTS


© IStockphoto

1. BUSINESS

1.1. Global production and legislation for dry sows

Production systems

There are approximately 80 million breeding sows globally[1]. The main housing system for dry sows are individual crates called sow stalls[2]; in these stalls, sows are unable to walk, turn around and rest comfortably. Sow stalls are mainly used for management purposes, allowing for individual feeding, artificial insemination and pregnancy checks, and to reduce aggression between sows. The length of time that sows can spend in stalls will vary dependent on the country's legislation (see Table 1). Sows enter the service phase where they are inseminated either artificially or with a boar. Sows are usually kept in stalls for service and can remain in stalls until pregnancy is confirmed (i.e. the observation period, around 4 weeks). If pregnancy is not confirmed, sows may remain in stalls until they have returned to heat (ovulation) and can be served again. If pregnancy is confirmed, sows may be moved to group housing or remain in stalls throughout their gestation period. If sow stalls are permitted for the whole of gestation, sows will spend around 108 days out of the average 150-day production cycle in sow stalls, which equates to ~77% of their productive life. One week before farrowing, sows will then move into farrowing crates for the duration of farrowing and lactation, until weaning when they are moved back into sow stalls, meaning sows may spend their entire productive life in stalls and crates. CIWF estimates that 88% of sows worldwide are kept in caged systems (farrowing crates and/or sow stalls).

Legislation

Some countries have banned the use of sow stalls during the entire gestation / dry period (e.g. the UK, Sweden, Norway, Switzerland and two US states), while others have partial bans in place (e.g. sow stalls are prohibited in the EU after the first 4 weeks of gestation; see Table 1 and Appendix A for more details). In the US, 60% of dry sows are housed in stalls, while the remaining 40% are now group housed in pens during part of the gestation period[3] (most are grouped after confirmation of pregnancy, i.e. after 28-35 days on average[4], but can be up to six weeks after service under state law – see Table 1). Australia has implemented a voluntary industry phaseout of sow stalls, with >90% of the industry using sow stalls for a maximum of 5 days post service.

TABLE 1 Summary of complete, partial or proposed legislation regarding the use of sow stalls.

Countries prohibiting sow stalls:	
Complete ban (inclusive of the observation period)	UK (1999), Norway (2000), Sweden (1988), Switzerland (1997), California (2015), Massachusetts (2022)
Partial ban (number of days / weeks post-service permitted in stalls)	EU (4 weeks), US states (6 weeks; Florida, Maine, Oregon, Arizona, Rhode Island, Colorado, Michigan, New Jersey & Ohio), Austria (10 days), Netherlands (4 days), New Zealand (7 days)
Proposed ban	Germany (2028), Canada (2029), Denmark (2035)

Following the successful European Citizen's Initiative "End the Cage Age" signed by 1.4 million European citizens, the European Commission committed in 2021 to revising its animal welfare legislation, and to introducing legislative proposals to phase out the use of cages for all farmed species in Europe, including sows, which is expected to be tabled from 2026.

Given this fast-evolving legislative landscape in several parts of the world, especially in Europe, it is crucial for producers and food companies to anticipate and adapt early on to those changes across their entire global supply. In geographies where there is no existing or forthcoming legislation, companies should still be looking to eliminate sow stalls from their supply through voluntary standards, to drive change and fall in line with the wider global trend towards cage-free production.

> *"Keeping sows in individual stalls is inevitably associated with poor welfare; stalls severely restrict sow movement to the extent that they have difficulty lying down and standing up (EFSA, 2007). Against this background, the European Citizens' Initiative (End the Cage Age, 2018) calls for an end to the use of stalls for pregnant gilts and sows."*
>
> EFSA[32]


© We Animals Media

1.2. A global movement towards sow stall-free sourcing

There is a growing global movement towards sow stall-free production; with increasing consumer perception of animal welfare in general and the welfare of breeding sows, and the need to address welfare issues in all geographies, companies are beginning to move towards sow stall-free sourcing across their entire supply chain.

CIWF's award programme is helping to drive this global movement, by celebrating and promoting sow stall-free commitments:

Good Pig Award

The **Good Pig Award** includes criteria for both sows and meat pigs to be implemented within 5 years. The Good Sow Commendation covers sows only and requires:

- No confinement in sow stalls during the dry period (including the observation period)
- No confinement during farrowing and lactation (farrowing crates)
- Provision of adequate manipulable material and bedding throughout life.

See our Good Pig Award Winners **here.**

Good Pig Production Award

The **Good Pig Production Award** is specifically for Chinese pig producers. It has criteria covering meat pigs and sows; for sows, one of the minimum requirements for entering the award is:

- No sow stalls (except for the observation period)

Additional criteria for sows are:

- No use of sow stalls (including the observation period)
- No use of farrowing crates
- Provision of appropriate manipulable material throughout life.

See our Good Pig Production Award Winners **here**.

Sow Stall Free Award

The **Sow Stall Free Award**, launched in 2024 and intended for companies in the Asia region, specifically focuses on ending the use of sow stalls and asks for:

- No confinement in sow stalls during the dry period (i.e. from weaning to 1 week prior to farrowing, with short occasional confinement allowed for management purposes, for a maximum of 4 hours at a time)
- No sourcing from multi-storey farms

See our Sow Stall Free Award Winners **here**.

In August 2024, we awarded our first Sow Stall Free Award to KPS Farm Nongpai Farm, a Thai pig producer, for implementing a 100% sow stall-free system throughout their pig farm operations.

Examples of companies with a sow-stall free commitment

Europe

fumagalli

Bompieri

Domino's (FR, DE, NL, LU)

IKEA (IT)

WAITROSE & PARTNERS

GREGGS

M&S EST. 1884

North America

THRIVE MARKET

CHIPOTLE MEXICAN GRILL

WHOLE FOODS MARKET

APPLEGATE NATURAL & ORGANIC MEAT

NIMAN RANCH Raised with Care

BUTCHERBOX

Pederson's NATURAL FARMS

Asia / Pacific

colesgroup *

Woolworths Group *

BETAGRO **

CPF **

NH Foods **

*Sows and gilts are kept in loose housing from at least five days after service until one week before farrowing.

**it is unclear if this commitment includes the observation period (from service until confirmation of pregnancy)

1.3. Costs of the transition and mitigation strategies

It is inevitable that converting a breeding farm operating with sow stalls to group housing facilities involves new capital expenditure, although this will vary due to different factors and the region of the world where producers operate. However, there are a number of ways to mitigate upfront costs.

Capital costs

One of the major costs of transition is the capital investment of sow stall-free housing. Rossi *et al*.[5] estimated that, in Italy, transition costs for renovated buildings range from EUR 682 per sow place to EUR 955 per sow place in 2021. Using two scenarios of retrofitting a building, capacity of the gestation housing is reduced by 27-38% depending on current building layout and group systems installed. New builds with a larger footprint could avoid reducing the herd size and were estimated at EUR 2,245-2,818 per sow place.

Lammers *et al*.[6] analysed the costs associated with different sow housing systems in the United States in 2007 and found that:

- The cost to build sow stalls was 32% higher per sow space compared to group housing systems. This means that if you were constructing a new sow housing system, choosing group housing would result in lower upfront costs.
- The total fixed costs (which include depreciation, interest, repairs, taxes, and insurance) for group housing were 83% of the total fixed costs for sow stall systems. This further supports the idea that group housing is more cost-effective in the long run, as it is cheaper to maintain and operate.

It was concluded that group housing is cheaper to build (lower initial investment) and run (lower fixed costs) compared to sow stalls.

A study in Canada in 2020 estimated that transition costs from sow stalls to group housing ranged from 250 to 750 CAD [Canadian dollar] per sow place (at the exchange rate of 1 CAD equals EUR 0.67, this is equivalent to EUR 168-503), but the cost of transitioning will vary depending on the type of design, use of existing infrastructure and producer input for labour[7]. The project also estimated that the cost of a renovation to existing buildings would be around 50-75% of the cost of a new group housing building[7].

Overall, the cost of transitioning from sow stalls to group housing will vary significantly depending on whether existing barns are retrofitted or new facilities are constructed, the size of the herd, and geographical location, as factors such as construction costs, labor expenses, and regulatory requirements differ across regions.

Production costs and impact on production levels

The impact of a transition on production costs will mainly vary in terms of whether producers have maintained or decreased their herd size. Increasing the herd size can help maintain production output but would also require additional capital investment. Running costs between stall and group housing systems are mainly affected by the use of straw and the feeding system[8]. Differences in running costs may also include energy, feed, veterinary bills, land management, certification costs etc[9]. However, in the long-term, labour costs and time requirements in indoor alternative systems are not estimated to vary greatly from conventional systems with sow stalls, which may reduce some production costs over time[10].

Research indicates that when properly implemented and managed, group housing systems provide similar levels of production to stalls. A project in Canada in 2020 found that producers moving from sow stalls to group housing reported no significant changes in production once the group housing system was established, and some producers reported that they had comparable conception rates and litter sizes before and after conversion[7].

Similarly, Mitchell *et al*.[11] compared different forms of housing on 8 farms in the Netherlands (2 farms), Spain (2 farms), and Brazil (4 farms), and found that group housing systems weaned more piglets than stall systems. Overall, they showed that group housing systems were as productive, if not more so, compared to stalls. Interestingly, they found that costs, as well as specifically feed costs, were on the whole lower in group housing systems compared to stalls, and that the group housing systems analysed had better net profits than the stall systems. They also concluded that the longer the farm is operating group housing systems, the better the system performs in terms of economics and profitability[11].

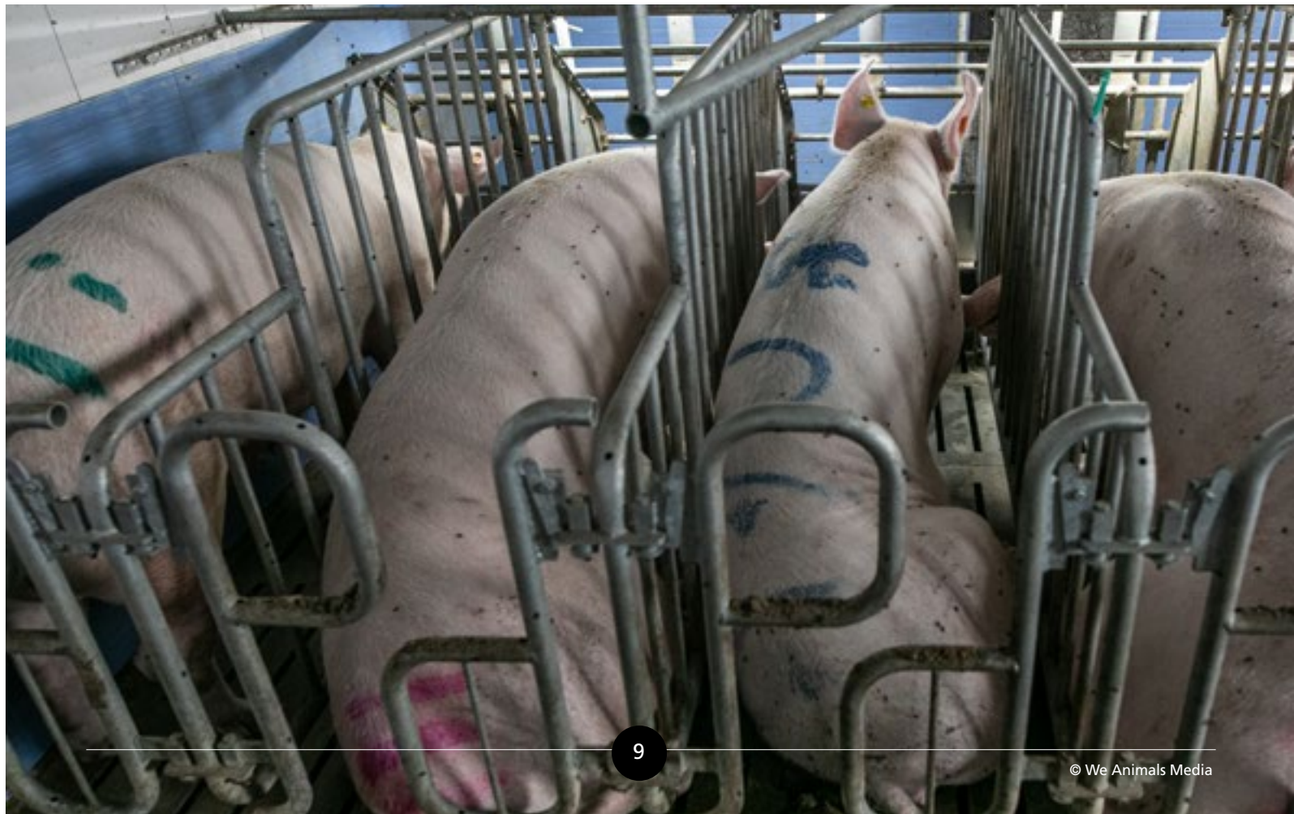
Reporting on Mitchell *et al*. [11], a study[12] carried out for Copa-Cogeca (an organisation representing farmers and agri-cooperatives in the EU) states:

> *"These case studies… demonstrated that group sow housing systems are viable in terms of economics and productivity. Often-cited perceptions of a negative impact on efficiency, higher operating costs or lower profits were not found. Investment costs are affected as the adoption of group housing implies several changes in the system, but some of these changes, such as the introduction of electronic sow feeding, could also increase efficiency. Evidence from the individual case studies showed better productivity for group housing, with more piglets at higher weights. In general, because of higher productivity and roughly similar / slightly lower feed costs and labour input across group housing systems, group housing offered a higher level of profitability."*
>
> Potori *et al.*[12]

Cost mitigation strategies

There are a number of strategies that can be implemented by the producer and the company to mitigate the increase in costs associated with a sow stall-free transition and maintain the economic viability of group housing systems.

It is vital that for transitioning out of stalls farmers are supported financially, such as receiving higher prices and long-term commitments from their buyer, market premiums for higher welfare products, Government support and promotion through marketing and certification schemes[10]. Market prices are an important determinant of farm revenue and profitability. Premiums are often available for products from cage-free / higher welfare systems. They vary greatly and can be sensitive to local market conditions but can be used to offset some costs of moving to cage-free production.



© We Animals Media

1.4 Invest in the best: Our recommendations for group housing of dry sows

There has been decades of research and commercial experience of how to successfully house sows in groups throughout service and gestation. Group housing systems should be designed and managed to minimise aggression and meet the welfare needs of dry sows by maintaining stable groups if possible and taking steps to reduce aggression when sows are mixed. This includes adequate space and opportunities for sows to escape from aggressive interactions, design of feeding systems to minimise competition, *ad libitum* feeding in the early mixing phase, high-fibre diets or permanent access to roughage, and good quality flooring with a substantial bedded area.

Dry sows should be kept in groups throughout the dry period, from weaning to one week prior to farrowing, including the observation period. Short duration confinement may be allowed for management purposes such as feeding and conducting artificial insemination but must be restricted to 4 hours or less at a time.

Recommendations for the successful group housing of dry sows

- Providing sufficient space (>3m^2 /sow), to allow sows to move away from each other. A higher space allowance will improve welfare, reduce aggression and piglet stillbirths.
- Managing aggression through good mixing practices (e.g. use of a specialized mixing pen with extra space and physical barriers for hiding, keeping a boar in the group, preventing competition at feeding, gradually familiarizing individuals via fence contact).
- Providing solid floors and bedding. Solid flooring with sufficient dry and clean bedding will positively impact thermal comfort, hoof condition, lameness incidence and skin lesions.
- Providing dietary fibre and manipulable materials, to satisfy hunger and fulfil foraging and exploratory needs. An appropriate diet and the provision of manipulable materials will reduce aggression and increase resting behaviour.

For more details, see our resource on **Indoor housing for dry sows – practical options**.

A meaningful sow stall-free commitment should:

- Be a commitment to only sourcing pork from producers that operate without sow stalls. Temporary confinement of sows is permitted for up to four hours for management procedures, such as insemination.
- Unless otherwise stated, group housing may still use sow stalls, from service to when pregnancy is confirmed. Therefore, it is key to explicitly state in the commitment to only source sow stall-free pork (i.e. no sow stalls throughout the dry period, inclusive of the service and observation period before confirmation of pregnancy).
- Cover a company's entire pork supply. All pork products should be covered by the company's sow stall-free commitment. If not, it is imperative to list which products are included to improve transparency.
- Have a clear, meaningful timeline for full implementation. CIWF recommends working to fully transition within five years of establishing a commitment.
- Be public facing with annual progress reporting towards meeting the commitment.

Example commitment:

"We are committed to sourcing 100% of our pork from supply chains that do not use sow stalls during the dry period (including the service and observation period before pregnancy confirmation) by 2028. To ensure full transparency, we will report this progress in our annual responsibility reports. As of 2024: 25% of our supply was produced without the use of sow stalls. Our supply is third-party audited to ensure compliance and traceability."

1.5 Marketing and communications opportunities

It is important to communicate about your commitment at an early stage and be proud of it:

- Ensure it is positioned clearly on your company's animal welfare policy pages.
- Clearly state what you will do and by when.
- The geographical boundaries of the commitment should be clear.
- Include any supportive quotes from other relevant partners such as NGOs.

A variety of marketing tactics can be explored to help communicate with customers on farm animal welfare and take them on the journey with you. It is important to share each challenge or success throughout the process and bring your consumer with you on the journey via regular updates. Don't just communicate at the start and the end of the process. Options to consider include:

Market research:

- Gather market analysis data to assess what your competitors are doing, which you can use in your marketing to highlight yourself as a leader in this space
- Understand consumer awareness of farm animal welfare and the drivers for purchasing higher welfare products
- Use surveys and focus groups to identify marketing strategies for increasing/supporting the demand for higher welfare products and to assess the willingness to pay for them

Messaging:

- Bring the consumer on the journey through regular public updates. When customers understand what cage-free really means for sow welfare, they are much more likely to choose higher-welfare products
- The messenger is as important at the message, so use 'trusted messengers' that consumers will respond positively to
- Focus on what's gained for both the animals and the consumer
- Keep messaging simple and positive
- Use language that consumers are using – be on the same page as them
- Communicate with the consumer of tomorrow

Animal welfare promotional campaign:

- Better for the animals
- Better for your health
- Better for the environment

Marketing channels:

- Shelf barkers and in-store communications
- On pack – use QR codes linking to the company website
- Social media
- TV and media
- Celebrity endorsement
- Outdoor advertising
- Leaflets – explain your animal welfare journey and highlight the work done by farmers that care for their animals in order to connect consumers and farming practices
- Recipe cards and associated promotions/ coupons for higher welfare products

Labelling:

- Ensure clear labels on products
- Include relevant certifications
- Help to drive consumer choice

Investors and NGOs are examples of other stakeholders that companies need to communicate with on their animal welfare policies, management and performance. There are tools created specifically to communicate with these stakeholders, for example the **Business Benchmark for Farm Animal Welfare** (BBFAW) and **CIWF's PigTrack** in the US which is a compliance tracking tool to measure company progress towards a higher welfare crate-free supply.

2. ANIMALS

Animal welfare encompasses both the physical and mental wellbeing of an animal as well as their ability to engage in behaviours that are important to them. To ensure good welfare, animals must be free from negative states, such as hunger, pain and fear, while also being able to experience positive states, such as pleasure and contentment. Sows have a number of innate behaviours that they are highly motivated to express, such as wallowing, exploration and foraging, and nest building. The ability to perform those innate behaviours is dependent on the provision of adequate space and access to diverse resources, such as manipulable materials like straw, in the housing system. While systems with a low welfare potential, i.e. sow stalls, will never be able to deliver good welfare due to their intrinsic limitations, systems with a higher welfare potential do not guarantee good welfare if they are not well managed. Therefore, it is important to manage group housing systems for dry sows appropriately, so that the welfare potential of the system can truly result in improved welfare for dry sows. Particular attention should be given to management risk factors that are associated with aggression around mixing and at feeding and with lameness, as well as providing opportunities for sows to express highly motivated behaviours such as foraging and rooting, and providing sufficient fibre to ensure satiety.

© IStockphoto

2.1. Health and physical welfare

2.1.1. Space restriction

Confinement is a serious welfare concern for dry sows. Sow stalls are on average 200-250cm in length and 50-70cm in width[13]. This means that, in a sow stall, the sow is provided with only enough space to stand up, lie down and move one or two paces back and forth; she is unable to turn around[14–16]. This restriction also means that sows cannot regulate their body temperature properly by moving to a more comfortable thermal environment[17].

Restriction in movement due to confinement causes sows' muscles and bones to weaken, leading to sows having difficulty standing up or lying down due to lack of exercise[15] and problems farrowing[18]. Restriction in movement also results in reduced cardiovascular fitness[19] and increases the risk of lameness[20,21], urinary tract infections[14,17] and limb injuries[21,22]. Limb injuries and lameness are also confounded by inappropriate, poorly maintained and slippery flooring[23].

Dry sows spend around 80% of their time lying down[24]. In stalls, dry sows are unable to adopt comfortable lying positions (i.e. lateral lying where pigs lie on their side with all legs stretched out[25]). Space restriction is increasingly exacerbated by increasing size of sows due to genetic selection which further reduces the amount of space for resting[26,27]. CIWF's recommendation is to use an allometric equation to calculate the space allowance per sow, and by accounting for the size of largest sows in the group or herd (for more information on the allometric curve calculation, see our resource **here**). CIWF recommends a minimum of $3m^2$/sow in group housing systems; increasing space allowance in dynamic groups from 2.25 to $3.0m^2$ per sow led to a significant reduction in one-way aggressions and lower mean number of injuries when sows were observed 3 and 8 days after mixing[28]. Sows housed at a space allowance of $3.3m^2$ per sow had the fewest skin lesions and had the largest litters compared to sows provided with $1.4m^2$ and $2.3m^2$ [29]. Therefore, providing sufficient space allowance reduces aggression and injuries[28].

2.1.2. Lack of comfort

Bare concrete floors with partially or fully slatted flooring cause injuries to the legs and claws while the sow gets up or lies down and becomes more severe throughout pregnancy[16]. Additionally, sores are caused by pressure on parts of the body while lying on bare concrete or slatted flooring with no bedding[30,31].

While sows prefer solid flooring over slats, sows cannot rest completely comfortably on bare concrete floors. The provision of deep bedding on top of solid flooring is important to improve sow comfort, including thermal comfort, reducing skin lesions [32,33] and leg injuries[34], and is generally considered to be the most appropriate flooring set up for group housing sows[35]. However, alternative substrates, such as rice husks and wood chip bark may be appropriate in warm climates where it is more important for the sow to keep cool. Lying mats have been shown to improve sow lying comfort compared to bare concrete and may be a suitable option in different regions and climates[24].

© We Animals Media

© We Animals Media

2.1.3. Lameness

Lameness is a major problem in commercial systems and is considered one of the main welfare issues for sows[36]. Lameness results in pain and discomfort[37–39], as well as increasing lying times which may cause increased prevalence of pressure lesions. Lameness can also impair reproductive performance[40,41], increase veterinary costs and increase workload for staff[36,42,43].

Claw injuries can be sustained on slatted floors where the slat width is too narrow, putting pressure on the sole, or the gap width is too large and claws get trapped, or the dew claw can be torn. One of the most common claw abnormalities is overgrowth of the weight bearing claws[30,44]. Damage to feet can also be caused by sharp edges or abrasive flooring. Poor hygiene on floors can make flooring slippery, increasing the risk of injuries from slipping, and will weaken the hoof, increasing the risk of infections[32]. There is a risk of lameness in group housed sows, particularly on slatted floors[45–47], therefore ensuring solid flooring and provision of deep bedding and effectively managing mixing in group housing systems is crucial[32].

2.1.4 Disease

Diseases pose an important health risk for confined sows. In intensive systems, higher stocking densities and poor ventilation can facilitate the spread of endemic diseases[48], and result in higher concentrations of air pollutants (e.g. dust and ammonia). Respiratory and digestive tract diseases are common in intensively reared sows. Stress associated with intensive production may also lead to an increased likelihood of pigs contracting disease[49], may shed more pathogens, such as zoonotic Salmonella[50] and develop gastric ulcers which are a prevalent and significant welfare issue in sows[51].

Disease control usually includes replacing ill or dead animals, vaccination programmes, or the use of antimicrobials for treatment or prophylaxis. The use of antimicrobials is more likely in intensive systems than in organic and free-range production[52], with possible long-term consequences for human resistance to antibiotics and other drugs. Antimicrobial resistance (AMR) is one of the greatest threats facing the human population. Overuse of antimicrobials in farming exposes bacterial populations in the environment to antimicrobial drugs, driving the development of resistant microbial populations[53]. There is strong evidence for animal–human transmission of antimicrobial resistance[54], thereby undermining the treatment of serious human disease[55].

2.1.4.1 African Swine Fever (ASF)

ASF is a serious viral disease. Pigs are mainly infected via the oro-nasal route through contact with infected pigs; slurry, vehicles, or equipment; workers or visitors; or by consuming contaminated pork or feed products (reviewed in[56, 57]).

The only real link between ASF infection risk and housing is in outdoor reared pigs coming into contact with wild boar[58]. To our knowledge, there are no studies showing a link between ASF infection and either group (indoor) housing or stalls; either system carries the same risks from the aforementioned routes of transmission.

Therefore, anecdotal claims that housing dry sows in groups impacts the risk of ASF infection are not supported by the scientific literature. Focussed efforts to reduce the risk of ASF being brought into a group housing system is recommended.

Bedding is often removed due to the perceived risk of introducing ASF virus into the system. While bedding can be a risk factor[59], this can be reduced through proper storage and treating bedding and other enrichment materials in a specific way to kill any potential virus [reviewed in [59–61]].

© IStockphoto

© Compassion in World Farming

2.2 Behavioural expression

2.2.1 Space limitations

Sow stalls do not provide sufficient space for sows to be able to behave normally. Curtis *et al*.[62] estimated that for sows to get up and lie down comfortably, a 300kg sow needs around 220cm in length and 86cm in width. Thus, a stall measuring less than 220 × 86cm will impede natural lying down and getting up behaviour[63]. Anil et al.[64] showed that the size (length and breadth) of sow stalls relative to the size of the sow has a negative association with standing time and the number of times sows moved from standing to sitting, indicating that the freedom of movement is impaired for sows housed in stalls. Confined sows show unresolved aggression (due to not being able to establish dominance hierarchies) and inactivity associated with unresponsiveness (reviewed in [14,17]). Confinement also prevents pigs from their naturally clean excretory behaviour where they create functional areas, including a specific dunging site[65]. This may result in sow discomfort while lying in sow stalls as they are unable to distance themselves from their urine and faeces. Finally, in stalls, sows do not have the space (or resources) to carry out exploratory or foraging behaviours, which leads to abnormal behaviours including stereotypic and re-directed oral behaviours (e.g.[66]).

Research shows that increased space allowances have a positive impact on sow behaviour, indicating an improvement on sow welfare (e.g.[67]). Providing sufficient space means sows can exhibit normal behaviours such as exploration[68] and resting[46]. Liu *et al*.[68] showed that group housed sows, provided with 5.04m^2/sow, exhibited more exploratory behaviour and less vacuum chewing (sham-chewing, a stereotypic behaviour), and lower concentrations of stress-related hormones (adrenocorticotrophic hormone and adrenaline) compared to sows housed in stalls throughout gestation. Weng *et al*.[69] compared the behaviour of sows housed in pens with 4 different space allowances: 2m^2/sow, 2.4m^2/sow, 3.6m^2/sow and 4.8m^2/sow. They found that the time spent rooting increased as the space allowance increased, while the time spent being inactive (sitting and standing) decreased in an inversely proportional relationship to space allowance[69]. Greenwood *et al*.[70] found that sows housed at 4m^2/sow and 6m^2/sow were more active, spent more time exploring and had more non-aggressive social interactions compared to sows housed at 2m^2/sow.


© iStockphoto


© We Animals Media

2.2.2 Barren environment

Sows are highly motivated to explore and forage[71,72]. In addition to physical confinement in stalls, sows are severely restricted in their exploratory and foraging behaviours due to the barren nature of stalls; stalls typically have slatted or solid concrete floors with no bedding which further restricts opportunities for foraging, exploring, and nest building in the run up to farrowing. As a result, they redirect this motivation into other oral behaviours, e.g. nosing, licking and biting towards the floor, trough, bars etc, and these behaviours may become stereotypic where they are performed in a routinised and repetitive way[73–75]. These stereotypies are associated with frustration due to the lack of stimulating environment[73,76,77]. Sows housed in stalls without straw were found to carry out stereotypical oral behaviours and motionless standing and sitting, and these behaviours were almost completely eliminated by the provision of deep straw bedding[78]. Similarly, Stewart *et al.*[79] also found that sows who had access to straw showed fewer stereotypic behaviours (head-thrusting, sham-chewing and bar-biting).

Deep straw bedding is most recommendable as bedding for dry sows (dependent on climate). For example, pregnant sows housed throughout gestation (3 days prior to insemination to one week prior to farrowing) with deep straw and 3.5m^2 had improved survival (within 12 hours after birth) of piglets compared to sows housed in pens with 2.4m^2 and slatted flooring and sows housed in pens with 2.4m^2 and manipulable wood and provision of straw pellets after meals[80]. Sows with deep straw also showed more positive social interactions, investigated and explored the straw more and had the fewest number of stereotypies[80].

It is important to note that even if forms of enrichment, such as straw or ropes, are provided, due to the very limited space in stalls, enrichment is mostly inadequate to meet the behavioural needs of the sows[32]. Therefore, group housing sows with sufficient space (i.e. >3m^2/sow) as well as provision of bedding and manipulable materials is crucial for improving the welfare of dry sows.

In order to effectively meet the needs of the sows, enrichment must be:

- **Investigable** so that sows can root through it with their snout;
- **Manipulable** so that sows can move it, and manipulate its appearance and structure;
- **Deformable / destructible** so that sows can bite and chew it;
- **Edible** so that sows can ingest the material;
- Provided in a way that ensures it **remains interesting** to the sows, regularly replenished, is **accessible** to all of the sows in the pen, and is **hygienic and safe**.[32,81]

2.2.3 Feed restriction and chronic hunger

Dry sows experience chronic hunger due to the type of feed given, quantity and the frequency of feedings. Sows are subject to feed restriction (up to 70% their ad libitum intake[82]) during pregnancy to avoid obesity and joint problems. Dry sows are fed a restricted diet typically of concentrates in the form of highly digestible pellets. While this feed can provide the necessary nutrients for good health, pigs will not feel satiated due to the short time spent eating, small feed portions and lack of fibre[73,83]. In these circumstances, feeding motivation will remain high and, if this cannot be expressed in an appropriate form of appetitive behaviour (searching, rooting, chewing), then abnormal behaviours (restlessness, aggression, oral stereotypies[73,84]), a high prevalence of stomach ulcers and frustration in sows can result[14].

Restrictive feeding during early pregnancy, beyond the first few days after mating, may adversely affect embryo survival and maintenance of pregnancy[85]. A Finnish study found that provision of roughage increased the likelihood of sows becoming pregnant[86]. Feeding high-fibre diets to sows during gestation has been found to have multiple benefits to productivity, including more successful insemination, larger litters, with more viable piglets, as well as benefits for piglet performance (reviewed in [87]). For example, Guillemet *et al*.[88] found that piglets from sows fed high-fibre diets during gestation showed improved growth rates during their first week of life and tended to be heavier at weaning.


© Compassion in World Farming

Feeding should be modified; dietary fibre should be increased by changing the concentrate diet, and by providing additional fibre-dense feedstuffs, for example, straw, haylage, and root vegetables. This extra substrate will also provide opportunities for foraging behaviour.

2.2.4 Social stress and aggression

In sow stalls, sows are in close proximity to other sows, which allows for visual contact but they cannot show signs of subordinance such as moving away from each other, meaning there is no effective way of establishing the hierarchy and tension between individuals is sustained[19]. Due to the inability to resolve the dominance rank order, such stress has a continuous effect throughout the period animals are kept in individual stalls.

Part of the rationale for keeping dry sows in stalls post-insemination, particularly for the first few weeks of gestation, stems from the concern of the negative impact of stressors during the early phase of pregnancy, and to promote embryo survival[89]. However, a large body of research has been published showing that housing sows in groups need not have any adverse effects on reproductive performance (e.g.[90–93]). In fact, a number of published reviews[13,94] and recent studies[95–97] indicate that reproductive performance in group housing systems (where group housing occurs either at the point of insemination or following some level of confinement) is comparable with that in stalls. Studies show that productivity is as high – or higher - in group housing as in sow stalls. Bates *et al.*[98] found that litter birth weight was higher in sows housed in groups with electronic sow feeders than in sows kept in stalls. Morgan *et al*.[99] found that group housing management during gestation was associated with better reproduction and productivity, as compared with the use of sow stalls. Fighting for social dominance in a newly formed group is a temporary activity, and while it is inevitable that there will be some fighting while the social hierarchy is formed within the group, the social hierarchy should be established before service is carried out, and the effect of this associated aggression can be effectively minimised.

From studies showing no adverse effects on reproductive performance of mixing during early pregnancy, it appears that sows are able to adapt to the transient stress of mixing[100–104] and that reproductive performance is unlikely to

be adversely affected unless stress is prolonged, for example if there is severe competition at feeding[105,106] or inadequate space to allow sows to escape aggressive interactions[107,108]. It is therefore likely that any adverse effects on reproductive performance reported in group housing systems are the result of inadequate design or management of systems rather than the result of mixing *per se*.

Good management and system design around mixing is paramount in ensuring reproductive performance is not negatively impacted, and to reduce the risk of injuries to sows, in particular subordinate sows. Key factors to manage potential aggression are gradual familiarisation of unfamiliar animals (via fence contact), sufficient space (e.g. a pen of 2.9m^2 was found to effectively reduce aggression during mixing compared to smaller pens[109]) and pen layout during mixing, and minimising opportunities for dominant sows to steal food from subordinates[33]. Using temporary specialised mixing pens which provide more space to escape aggressors[109–111], barriers to hide behind[112], and square pens (rather than circular, triangular or rectangular pens)[113] can be effective at reducing aggression at mixing. Providing manipulable material such as straw or other organic materials like mushroom compost or rice husks may also reduce aggression by offering opportunities for rooting and foraging, minimising frustration which can exacerbate aggression[114]. *Ad libitum* feeding at the time of mixing is effective at reducing aggression[115,116], as well as providing high satiety (high fibre) diets[117,118]. The use of dynamic groups should be avoided where possible, but if they are used, aggression should be managed by minimising the number of mixing occasions, using specialised mixing pens and grouping sows of similar sizes[32].

Therefore, there is no justification for the individual housing of sows in the period from weaning of the piglets, for the first one to four weeks after service, or for the whole of gestation until one week prior to farrowing (when they are moved into farrowing housing). Indeed, aggression and stress are likely to be minimised if sows are returned to groups as soon as possible after any period of separation (e.g. during farrowing and lactation or for service), and appropriate design and management of group housing systems are ensured.

2.3. Mental welfare

Pigs are intelligent and social animals, with a complex range of behaviours and needs. Sows can experience complex negative and positive emotional states, such as fear, stress, frustration, contentment and pleasure, which are measured by behavioural[119] and physiological changes[120,121]. When confined to a sow stall, sows are unable to perform highly motivated behaviours, such as foraging, or interacting socially with other pigs. As a result, confined sows can show higher incidences of aggressive behaviours and abnormal behaviours, such as stereotypies (e.g., repetitive bar biting or head swaying) due to frustration, boredom, stress and hunger[122]. These behaviours can indicate poor mental welfare outcomes because they are considered to occur when pigs are attempting to cope in an inappropriate environment[123,124].

Positive experiences are equally as important as the absence of negative experiences in order for animals to have a good life[125–127]. In sows, behavioural indicators of positive affective states include rooting and foraging, exploration, resting and nest building in the lead up to farrowing. Therefore, promoting these behaviours, for example by providing straw or outdoor areas, are important for promoting positive affect so that sows can have a good life.

2.4 Assessing welfare

Welfare outcomes are an animal-based method of assessing an animal's physical wellbeing and increasingly their behavioural expression and mental wellbeing. Whilst provision of certain resources (inputs) in the sow's environment is necessary to increase the welfare potential of a system, measuring animal-based outcomes indicates whether that potential has been met, and so is still important to carry out in cage-free systems. Regularly scoring appropriate outcome measures can help to identify welfare problems and be used to set targets or benchmark for improvements through an active programme.

The main welfare measures recommended for dry sows are:

- Lameness
- Ear and flank biting
- Body condition
- Shoulder and vulva lesions
- Mortality and longevity
- Behaviours including rooting/foraging, aggression, redirected behaviours e.g. bar biting.

EXAMPLE: Dongnong Sanhua Pig Farm

Dongnong Sanhua Pig are a group enterprise which owns three pig breeder-to-finishing farms in Harbin, China. They set out to design and implement a completely stall free system whereby the farm does not use stalls or crates at any stage of service, observation, pregnancy, farrowing or lactation of sows.

Sows are moved into groups of 15-20 once weaning has finished. After 5-7 days, artificial insemination is undertaken in groups, and observation / confirmation of pregnancy takes place. Sows remain in these static groups for the duration of the pregnancy until 1 week prior to farrowing. Aggression is monitored by staff and reported to peak within 3-5 hours of mixing and subsequently reduces in the following 24 hours. Although minor lameness can still occur at mixing due to aggression, it is reported that it does not reach high levels of severity. Lameness and mortality are both reported as an average of 1-2% per year.

Sows are housed on solid floors and straw is added into each pen at mixing and topped up once a day for the duration of the pregnancy. Manipulable materials, such as straw, as well as adequate space provision (3.5m^2/sow), also contribute to reduced aggression within the groups, as they promote more positive exploratory behaviours.

When comparing sows reared in group housing to those in sow stalls, the farm has seen no detrimental impact on production. The farm also reports a 90% successful farrowing rate in their free farrowing pens, higher than the industry average on farrowing crates of around 85%. They attribute this success to reduced stress levels throughout the pregnancy.

Other benefits of group housing recorded include: a longer production life (average 8-10 litters per sow) and a reduction in staff labour due to the Electronic Sow Feeding (ESF) system installed in 2015. Since replacing trough feeders with the ESF system, the farm has seen an improvement in body condition of sows owing to the precise feed amount in relation to individual weights.

Management of sows has become easier where labour is not being spent on manual feeding. It is also reported that sows appear more resistant to health challenges, likely due to improved space allowance and reduced stress levels, in comparison to sows confined in stalls.

For more information on Dongnong Sanhua Farm, see our detailed case study **here**.

© Dongnong Sanhua Pig Farm

© iStockphoto

3. PEOPLE

3.1. Consumer attitudes

Consumers are increasingly concerned about how their food is produced and the welfare of the animals involved. Studies across the EU, North America, Latin America, Asia and Australia indicate that animal welfare concerns have become more important to consumers over the past two decades[128].

According to the latest Eurobarometer on Animal Welfare[129], the vast majority (91%) of EU citizens believe it is important to protect the welfare of farmed animals, eight in ten (84%) believe the welfare of farmed animals should be better protected than it is now, and six in ten (60%) are willing to pay more for products from animal welfare-friendly production systems. Around a quarter (26%) would be ready to pay up to 5% more, 6% would be ready to pay more than 20% more but 37% (nearly 4/10 respondents) are not ready to pay more. Additionally, 89% of EU citizens surveyed believe that it is important that farm animals are not kept in individual cages.

Consumers around the world (across Asia, Europe and North America) show concern for animal welfare, including pigs[130]. Consumers' main concerns regarding pig welfare relate to living conditions[131,132] including outdoor access[133–136], space allowance[132,133,136,137], freedom of movement[2,133,136,138], provision of a littered floor/straw bedding[133,135,139], and avoidance of pain/mutilations[134,136,140].

Consumers show widespread opposition to the confinement of sows in stalls (US and Canada[2], Germany and Poland[138, 141]). Provision of additional information about housing systems increases opposition to confinement systems and support for group housing systems[2]. 83% of surveyed Chinese consumers said they wanted sows to be given freedom to move (preferring group housing to stalls) and more than 75% said they would be willing to pay more for this[141].

Motivation to purchase higher-welfare pork is influenced by consumer perceptions that animal welfare is positively related to product quality (Europe[142]; China[143]; Poland, Italy, Japan and South Korea[144]), taste (Europe[142]; China[143]), healthiness (Europe[142]), and food safety (China[139,143]). Seven in ten urban Chinese consumers surveyed in Shanghai and Beijing believe animals that are treated well taste better and are safer to eat[143].

Studies in various countries have demonstrated that consumers are willing to pay for better pig welfare; around half of consumers surveyed in China (54.5%) and Italy (47%) are willing to pay more for higher welfare pork (China[139]; Italy[145]) while the majority of those surveyed in Denmark (75%), Germany (69%) and Sweden (55%) were willing to pay a price premium for welfare-labelled Danish pork (the lower proportion for Swedish consumers is likely because the welfare standards for the label were similar to legal standards in Sweden)[161].


© iStockphoto

3.2 Farmers

There are sometimes negative perceptions around labour efficiency in group housing systems due to the increased need for monitoring social interactions, maintaining cleanliness, and ensuring all sows receive adequate feed. However, producers can reduce these requirements through improved facility design, automation, and staff training, ultimately enhancing efficiency over time. For instance, electronic sow feeding systems can significantly improve labour efficiency by minimising the need for manual feeding[11].

In Australia, pork producers began a voluntary phase out of sow stalls in 2010. By 2020, the majority (>91% of dry sows) of Australian pig producers had transitioned to group housing systems (sows can be housed in stalls for the first five days following insemination). The CEO of Australian Pork Limited stated that one of the biggest motivations for farmers was the industry's relationship with consumers[147], highlighting the importance of consumer demand for higher welfare products. This is a clear example of how pig farmers can successfully lead a voluntary transition to group housing of dry sows.

Training of staff is vital to ensuring a successful transition to group housing to reduce the risk of problems arising, mainly around mixing and aggression. Group housing systems require different skills, knowledge and experience to sow stalls. Training of staff to recognise when issues are occurring, particularly during mixing and during handling around service and pregnancy diagnosis, is crucial[32]. Proper training will aid performance, production, animal health and welfare, and worker safety, leading to economic benefits and job satisfaction for workers. Companies should provide support for their producers in the form of education and training in how to set up and manage a sow stall free system.

4. PLANET

Aspects of housing and management can have a direct impact on the environmental footprint of the farm, including level of animal confinement, stocking density, housing design, scale of the operation, composition and sources of feed and waste disposal. High numbers of livestock in a small area increased the amount of waste and nutrient run-off into the local environment, leading to pollution. While waste management can still be a concern in smaller systems, for example due to the cost-effectiveness of some technologies, or nitrogen losses in outdoor systems, good management can mitigate these effects[9]. Different methods can be employed to mitigate the effects of pig production on the environment and climate targets. While there is limited research on the direct environmental impact of moving from sow stalls to group housing, in this section we discuss how to mitigate environmental impacts of pig farming in general.

Waste management

Changes to slurry storage have been found to reduce methane emissions; frequently moving slurry from pig houses and into outside storage, thereby reducing slurry retention time, and combining with an anaerobic digestor can reduce methane emissions by over 50%[148]. The use of anaerobic digestors is also effective in improving the sustainability of farms by mitigating greenhouse gas emissions, producing biogas for on-farm heat, electricity, and fuel, as well as fertilisers[149].

Feed

Feed (source, composition and transport) is crucial in improving the sustainability of pig production; feed has been identified as the largest source of environmental impact associated with pig production[150,151]. Feed production, including each ingredient life cycle, fabrication and transport, has been found to account for as much as 76% of the total greenhouse gas emissions for pig production[151]. Alternative feed sources that do not compete with food that can be consumed directly by humans need to be used, such as waste or by-products of the food industry and certain household waste[152–155].


© Compassion in World Farming

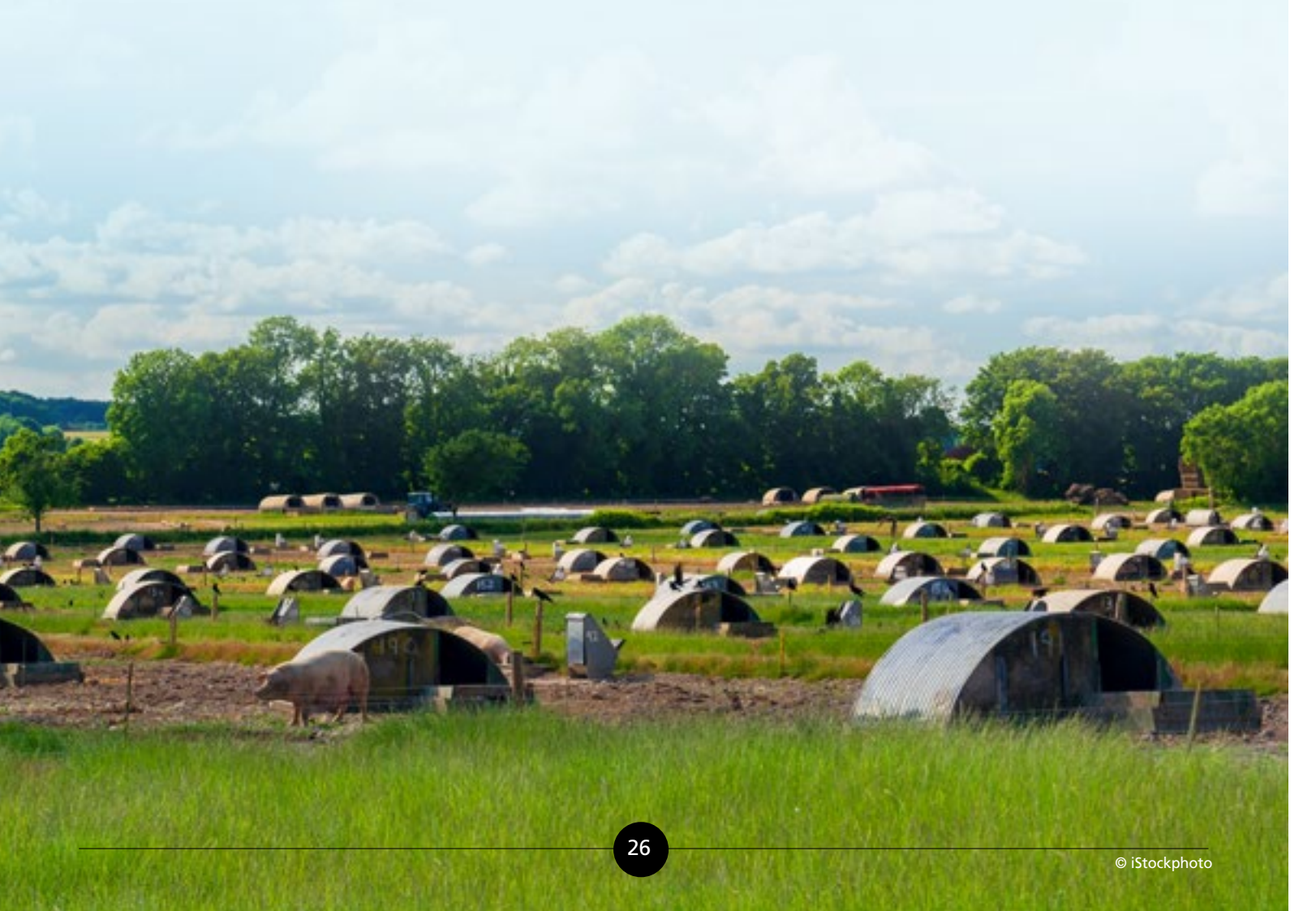
Alternative systems

A broader approach to sustainability needs to ensure good animal welfare while also minimizing the environmental impact of farming systems. In particular, regenerative systems provide environmental opportunities e.g. increased biodiversity from more complex habitats displacing intensively fertilised grassland, while also offering a high welfare potential for the pigs. While outdoor housing systems are often found to have an overall lower eutrophication potential than indoor systems per kg of output (e.g.[120]), careful management is required outdoors to lower the impact of nitrogen losses and soil damage[121]. Furthermore, to minimise the risk of over-fertilisation and over-rooting, outdoor housing should regularly be moved to a new area of land[122].

There are also other broader sustainability benefits to higher welfare systems, such as lower risk of disease outbreak and zoonotic pandemics, and lower use of antibiotics and therefore lower risk of antibiotic resistance, which have critical implications for human health.

Meat consumption

In addition to reducing the environmental impact of farming practices, a rebalancing of protein, away from a reliance on intensively produced animal sourced foods to a more diverse and sustainable diet with less reliance on animal sourced products (by promoting the consumption of natural based proteins (such as fruit, vegetables and pulses), plant-based meat alternatives, fermented protein alternatives, and cultivated (cell-based) alternatives), will be key to a future-fit, humane and sustainable food system[156,157,158,159,160].



EXAMPLE: Zonvarken Pig Cooperative

Zonvarken is a Dutch farming cooperative established in 2018. The Zonvarken concept aims to have a farming system which benefits pigs, the farmer, and the environment. They operate higher welfare systems where sows are never confined; instead, sows are group housed with access to an outdoor grass covered orchard area (~1 Ha) with trees and a wallowing area. Zonvarken uses an innovative 'Separate Floor' system (patent-pending), which separates the solid faeces and urine directly. The solid manure is removed several times a day by means of a moving floor system (devised by Tangelder Techniek). This process has reduced ammonia emissions by about 70%. This manure management process has resulted in a large reduction (up to 90%) in methane. Additionally, by incorporating straw in the solid manure, the manure can be converted into bokashi, a high-quality fertiliser made of fermented organic material which can be used to improve soil health.

Zonvarken uses feed made from return flows and residual flows (waste products and by-products) from the human food industry. Their supplier 'Voerwaarts' specialises in making animal feed from residual food waste. They obtain a large part of the raw materials from FeedValid, a leading party in the collection of food return flows such as stale bread and broken crackers. Thus, no agricultural land is used to grow feed specifically for the Zonvarken pigs, resulting in feed that has an approximately 60% lower CO^2 footprint than conventional pig feed. Additionally, as the feed is made from waste, there is no direct or indirect food competition with people.

For more information on Zonvarken, see our detailed case study **here**.

CONCLUSION

Individual companies, governments, and consumers are increasingly driving a global market shift to sow stall-free pig production. There is a large body of evidence showing the welfare benefits of cage-free group housing systems for dry sows, while studies show no adverse effect of group housing on reproductive performance, if appropriate pen design and management of group housing systems are ensured. Producers who have made the transition show that sow stall-free production is economically viable. Animal welfare is an integral part of a sustainable model of pig production, and only cage-free systems have the potential to deliver good welfare while improving brand reputation and meeting societal demand for ethical food.

There are also other broader sustainability benefits to higher welfare systems, such as lower risk of disease outbreak and zoonotic pandemics, and lower use of antibiotics and therefore lower risk of antibiotic resistance, which have critical implications for human health.

Further reading

Indoor housing for dry sows – practical options

Case study on Zonvarken Cooperative farm

Case study on group housing sows in China

US Pigtrack report tracking US company commitments to gestation crate-free pork

Report on Food Businesses paving the way for a cage-free Europe

ANNEX I

Summary of legislation on the use of sow stalls

EU

Minimum standards for the protection of pigs in the EU are laid down in Council Directive 2008/120/EC (codified version, which includes a partial ban on sow stalls – stalls are permitted for the first 4 weeks post-service, and covers space allowances, provision of manipulable materials and mutilations. Some individual Member States and some other European nations (Norway, Sweden, Switzerland, forthcoming ban in Germany (2028) and Denmark (2035)) have completely prohibited sow stalls (inclusive of the observation period).

Other countries have partial bans: in Austria, the use of sow stalls has been limited to ten days since 2013. In the Netherlands, the use of sow stalls is limited to four days since 2013.

UK

Minimum standards for the protection of pigs in the UK are laid down in The Welfare of Farmed Animals (England) Regulations 2007 (as amended, and related Regulations in other parts of the UK), which include a full ban on sow stalls and requirements for space allowances and provision of environmental enrichment.

US

There is no federal legislation protecting the welfare of pigs during rearing (only during transport and slaughter). Eleven US States have restricted the use of sow stalls for sows (year of full implementation in parentheses). Florida (2008), Maine (2011), Oregon (2012), Arizona (2013), Rhode Island (2013), Colorado (2018), Michigan (2020), New Jersey (2023) and Ohio (2026) only require group housing following confirmation of pregnancy, so dry sows may be kept in crates up to six weeks. California (2015, further measures in 2022) and Massachusetts (2022) have passed the strongest policies prohibiting both the production and sale of pork produced with any gestation crates use. California also requires dry sows are provided a minimum of 2.2 m^2 (24 ft^2) of floor space per sow, surpassing the industry standard of 1.3 m^2 (14 ft^2) in crates.

CANADA

Canada made a commitment to end the use of sow stalls by 2024, but the deadline has been pushed back to 2029 due to industry intervention and it does not include existing installations.

BRAZIL

Brazil has general anti-cruelty legislation but there is currently no specific legislation establishing minimum welfare standards for pigs in Brazil.

CHINA

There is currently no specific legislation establishing minimum welfare standards for the rearing of pigs in China (only some basic requirements on slaughter).

AUSTRALIA

There is a voluntary phase out of sow stalls in Australia – the deadline for this voluntary ban was 2017. In 2020, around, around 91% of production was completely sow stall-free. Sows can still be crated in mating stalls for the first 5 days after service.

NEW ZEALAND

Sow stalls were banned in 2015 under the Animal Welfare Act in New Zealand, although stalls are permitted for the first 7 days post-service.

REFERENCES

[1] USDA. State Policies for Farm Animal Welfare in Production Practices of U.S. Livestock and Poultry Industries: An Overview. https://www.ers.usda.gov/webdocs/publications/105481/eib-245.pdf?v=3802.9 (2022).

[2] AZSOS. Arizona Administrative Register. https://apps.azsos.gov/public_services/register/2022/16/contents.pdf?time=1651449600169 (2022).

[3] GCAW. GCAW POSITION ON COMBINATION SYSTEMS FOR LAYING HENS. https://www.gc-animalwelfare.org/wp-content/uploads/2023/06/GCAW-Position-on-Combination-Cages-June-2021.pdf (2021).

[4] Caputo, V., Staples, A. J., Tonsor, G. T. & Lusk, J. L. Egg producer attitudes and expectations regarding the transition to cage-free production: a mixed-methods approach. Poultry Science 102, 103058 (2023).

[5] Yilmaz Dikmen, B., İpek, A., Şahan, Ü., Petek, M. & Sözcü, A. Egg production and welfare of laying hens kept in different housing systems (conventional, enriched cage, and free range). Poultry Science 95, 1564–1572 (2016).

[6] Best Practice Hens. Home. Best Practice Hens https://bestpracticehens.eu/.

[7] Matthews, W. A. & Sumner, D. A. Effects of housing system on the costs of commercial egg production1. Poultry Science 94, 552–557 (2015).

[8] Stadig, L. M. et al. Opinion of Belgian Egg Farmers on Hen Welfare and Its Relationship with Housing Type. Animals 6, 1 (2016).

[9] Eurogroup for Animals. Phasing out Cages in the EU: The Road to a Smooth Transition. https://www.eurogroupforanimals.org/files/eurogroupforanimals/2023-03/NALB-Phasing%20out%20cages-final.pdf (2023).

[10] de Luna, M. C. T. et al. Cage egg producers' perspectives on the adoption of cage-free systems in China, Japan, Indonesia, Malaysia, Philippines, and Thailand. Frontiers in Veterinary Science 9, (2022).

[11] Kritsa, M. Z., Tsiboukas, K., Sossidou, E. N., Simitzis, P. E. & Goliomytis, M. Partial budget analysis of laying hens' transition from cages to production systems of improved welfare: a case study in Greece. British Poultry Science 0, 1–10 (2024).

[12] Kato, H. et al. Estimating production costs and retail prices in different poultry housing systems: conventional, enriched cage, aviary, and barn in Japan. Poultry Science 101, 102194 (2022).

[13] Van Horne, P. L. M. & Bondt, N. Competitiveness of the EU egg sector, base year 2015: international comparison of production costs. https://library.wur.nl/WebQuery/titel/2214587 (2017).

[14] Oliveira, L. S. N. et al. Economic Feasibility in Commercial Egg Production in a Conventional and Cage-Free Systems with Different Stocking Densities. Braz. J. Poult. Sci. 24, eRBCA (2022).

[15] Wageningen Economic Research & Best Practice Hens. Costs and Benefits of Alternative Systems for Egg Production. https://bestpracticehens.eu/wp-content/uploads/2022/08/17-PA-Costs-and-benefits.pdf (2022).

[16] Nicol, C. J. et al. Farmed Bird Welfare Science Review. (Melbourne: Department of Economic Development, Jobs, Transport and Resources., 2017).

[17] EFSA. Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to the welfare aspects of various systems of keeping laying hens. EFSA Journal 3, 197 (2005).

[18] Schuck-Paim, C., Negro-Calduch, E. & Alonso, W. J. Laying hen mortality in different indoor housing systems: a meta-analysis of data from commercial farms in 16 countries. Sci Rep 11, 3052 (2021).

[19] Kaufmann-Bart, M. & Hoop, R. K. Diseases in chicks and laying hens during the first 12 years after battery cages were banned in Switzerland. Veterinary Record 164, 203–207 (2009).

[20] Shini, A., Stewrat, G. D., Shini, S. & Bryden, W. L. Free range housing systems: performance from three consecutive laying cycles. in (2008).

[21] Sherwin, C. M., Richards, G. J. & Nicol, C. J. Comparison of the welfare of layer hens in 4 housing systems in the UK. British Poultry Science 51, 488–499 (2010).

[22] Ellen, E. D. et al. The prospects of selection for social genetic effects to improve welfare and productivity in livestock. Front. Genet. 5, (2014).

[23] Ellen, E. D. et al. Review of Sensor Technologies in Animal Breeding: Phenotyping Behaviors of Laying Hens to Select Against Feather Pecking. Animals 9, 108 (2019).

[24] Fernyhough, M., Nicol, C. J., van de Braak, T., Toscano, M. J. & Tønnessen, M. The Ethics of Laying Hen Genetics. J Agric Environ Ethics 33, 15–36 (2020).

[25] Rowland, L. O. & Harms, R. H. The Effect of Wire Pens, Floor Pens and Cages on Bone Characteristics of Laying Hens1. Poultry Science 49, 1223–1225 (1970).

[26] Sandilands, V., Moinard, C. & Sparks, N. H. C. Providing laying hens with perches: fulfilling behavioural needs but causing injury? British Poultry Science 50, 395–406 (2009).

[27] Wilkins, L. J. et al. Influence of housing system and design on bone strength and keel bone fractures in laying hens. Veterinary Record 169, 414–414 (2011).

[28] Stratmann, A. et al. Modification of aviary design reduces incidence of falls, collisions and keel bone damage in laying hens. Applied Animal Behaviour Science 165, 112–123 (2015).

[29] Harlander-Matauschek, A., Rodenburg, T. B., Sandilands, V., Tobalske, B. W. & Toscano, M. J. Causes of keel bone damage and their solutions in laying hens. World's Poultry Science Journal 71, 461–472 (2015).

[30] Käppeli, S., Gebhardt-Henrich, S. G., Fröhlich, E., Pfulg, A. & Stoffel, M. H. Prevalence of keel bone deformities in Swiss laying hens. British Poultry Science 52, 531–536 (2011).

[31] Scholz, B., Kjaer, J. B. & Schrader, L. Analysis of landing behaviour of three layer lines on different perch designs. British Poultry Science 55, 419–426 (2014).

[32] Stratmann, A. et al. Soft Perches in an Aviary System Reduce Incidence of Keel Bone Damage in Laying Hens. PLOS ONE 10, e0122568 (2015).

[33] EFSA Panel on Animal Health and Animal Welfare (AHAW) et al. Welfare of laying hens on farm. EFSA Journal 21, e07789 (2023).

[34] Heerkens, J. L. T., Delezie, E., Ampe, B., Rodenburg, T. B. & Tuyttens, F. A. M. Ramps and hybrid effects on keel bone and foot pad disorders in modified aviaries for laying hens. Poultry Science 95, 2479–2488 (2016).

[35] RSPCA. RSPCA Welfare Standards for Laying Hens. https://science.rspca.org.uk/documents/1494935/9042554/Perch+standards+implementation.pdf/e329840a-f1aa-e85e-6d52-5749ca527bfe?t=1553171065983 (2017).

[36] WANG, G., EKSTRAND, C. & SVEDBERG, J. Wet litter and perches as risk factors for the development of foot pad dermatitis in floor-housed hens. British Poultry Science 39, 191–197 (1998).

[37] Weitzenbürger, D., Vits, A., Hamann, H., Hewicker-Trautwein, M. & Distl, O. [Evaluation of foot pad health of laying hens in small group housing systems and furnished cages]. Berl Munch Tierarztl Wochenschr 118, 270–279 (2005).

[38] Vits, A., Weitzenbürger, D., Hamann, H. & Distl, O. Production, egg quality, bone strength, claw length, and keel bone deformities of laying hens housed in furnished cages with different group sizes. Poultry Science 84, 1511–1519 (2005).

[39] Pickel, T., Schrader, L. & Scholz, B. Pressure load on keel bone and foot pads in perching laying hens in relation to perch design. Poultry Science 90, 715–724 (2011).

[40] Xie, R. et al. The episodic resurgence of highly pathogenic avian influenza H5 virus. Nature 622, 810–817 (2023).

[1] Genesus. World Mega Producer. https://genesus.com/wp-content/uploads/2022/06/WMP-2022-booklet-20-web.pdf (2022).

[2] Ryan, E. B., Fraser, D. & Weary, D. M. Public Attitudes to Housing Systems for Pregnant Pigs. PLOS ONE 10, e0141878 (2015).

[3] Johnston, J. Prop 12 a lost battle in a larger war NPPC. Meatingplace https://www.meatingplace.com/Industry/News/Details/109693 (2023).

[4] National Pork Board. PQA Plus 1® Version 5 Education Handbook. https://www.porkcdn.com/sites/lms/References+and+Resources/PQAv5+Handbook+English+2.8.22.pdf (2021).

[5] Rossi, P., Motta, A., Montanari, C., Gastaldo, A. & Emilia, R. Valutazione dell'impatto economico dell'eliminazione delle gabbie negli allevamenti suinicoli. (2021).

[6] Lammers, P. J., Honeyman, M. S., Klienbenstein, J. B. & Harmon, J. D. Impact of Gestation Housing System on Weaned Pig Production Cost. Applied Engineering in Agriculture 245–249 (2007).

[7] Richards, D. et al. National Sow Housing Conversion Project. (2020). https://www.prairieswine.com/wp-content/uploads/2020/11/National-Sow-Housing-Conversion-Project-1.pdf

[8] Commission. EUR-Lex - 52001DC0020 - EN. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52001DC0020.

[9] Kollenda, E., Baldock, D., Hiller, N. & Lorant, A. Transitioning towards Cage Free Farming in the EU. https://ieep.eu/wp-content/uploads/2024/02/Transitioning-towards-cage-free-farming-in-the-EU_Final-report_October_web-1.pdf (2020).

[10] Eurogroup for Animals. Phasing out Cages in the EU: The Road to a Smooth Transition. https://www.eurogroupforanimals.org/files/eurogroupforanimals/2023-03/NALB-Phasing%20out%20cages-final.pdf (2023).

[11] Mitchell, L. The pig industry's transitions to group sow housing ; economic and welfare assessment. (2017).

[12] Potori, N. et al. An assessment of the impacts of the phasing out of cages in EU livestock farming: the pig and layer sectors. Final Report (2023).

[13] McGlone, J. Sows stalls - a brief history. Pig Progress (2013).

[14] EFSA, E. F. S. Animal health and welfare aspects of different housing and husbandry systems for adult breeding boars, pregnant, farrowing sows and unweaned piglets - Scientific Opinion of the Panel on Animal Health and Welfare. EFSA Journal 5, 572 (2007).

[15] Marchant, J. N. & Broom, D. M. Factors affecting posture-changing in loose-housed and confined gestating sows. Animal Science 63, 477–485 (1996).

[16] Boyle, L. A. Effect of stage of gestation on lying behavior of sows in crates. Proceeding of the Agricultural Research Forum, Tullamore, Cork (2008).

[17] SVC, E. The Welfare of Intensively Kept Pigs. Report of the EU Scientific Veterinary Committee. http://europa. eu. int/comm/food/fs/sc/scah/out71_en. pdf. (1997).

[18] Gu, Z. et al. Impacts of a freedom farrowing pen design on sow behaviours and performance. Preventive Veterinary Medicine 102, 296–303 (2011).

[19] Marchant, J. N., Rudd, A. R. & Broom, D. M. The effects of housing on heart rate of gestating sows during specific behaviours. Applied Animal Behaviour Science 55, 67–78 (1997).

[20] Barnett, J. L., Hemsworth, P. H., Cronin, G. M., Jongman, E. C. & Hutson, G. D. A review of the welfare issues for sows and piglets in relation to housing. Aust. J. Agric. Res. 52, 1–28 (2001).

[21] Calderón Díaz, J. A., Fahey, A. G. & Boyle, L. A. Effects of gestation housing system and floor type during lactation on locomotory ability; body, limb, and claw lesions; and lying-down behavior of lactating sows1. Journal of Animal Science 92, 1675–1685 (2014).

[22] Leeb, B., Leeb, Ch., Troxler, J. & Schuh, M. Skin Lesions and Callosities in Group-Housed Pregnant Sows: Animal-Related Welfare Indicators. Acta Agriculturae Scandinavica, Section A — Animal Science 51, 82–87 (2001).

[23] KilBride, A. L., Gillman, C. E. & Green, L. E. A cross sectional study of the prevalence, risk factors and population attributable fractions for limb and body lesions in lactating sows on commercial farms in England. BMC Vet Res 5, 30 (2009).

[24] Tuyttens, F. A. M., Wouters, F., Struelens, E., Sonck, B. & Duchateau, L. Synthetic lying mats may improve lying comfort of gestating sows. Applied Animal Behaviour Science 114, 76–85 (2008).

[25] McGlone, J. J., Vines, B., Rudine, A. C. & DuBois, P. The physical size of gestating sows1. Journal of Animal Science 82, 2421–2427 (2004).

[26] Edwards, S. A. Nutrition of the rearing gilt and sow. Progress in pig science. (1998).

[27] Moustsen, V. A., Lahrmann, H. P. & D'Eath, R. B. Relationship between size and age of modern hyper-prolific crossbred sows. Livestock Science 141, 272–275 (2011).

[28] Remience, V. et al. Effects of space allowance on the welfare of dry sows kept in dynamic groups and fed with an electronic sow feeder. Applied Animal Behaviour Science 112, 284–296 (2008).

[29] Salak-Johnson, J. L., Niekamp, S. R., Rodriguez-Zas, S. L., Ellis, M. & Curtis, S. E. Space allowance for dry, pregnant sows in pens: Body condition, skin lesions, and performance1. Journal of Animal Science 85, 1758–1769 (2007).

[30] Bonde, M., Rousing, T., Badsberg, J. H. & Sørensen, J. T. 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, 179–187 (2004).

[31] Rioja-Lang, F., Seddon, Y. & Brown, J. A. Shoulder lesions in sows: A review of their causes, prevention, and treatment. Journal of Swine Health and Production 26, 101–107 (2018).

[32] EFSA Panel on Animal Health and Welfare (AHAW) et al. Welfare of pigs on farm. EFSA Journal 20, e07421 (2022).

[33] Spoolder, H. A. M., Geudeke, M. J., Van der Peet-Schwering, C. M. C. & Soede, N. M. Group housing of sows in early pregnancy: A review of success and risk factors. Livestock Science 125, 1–14 (2009).

[34] Andersen, I. L. & Bøe, K. E. Straw Bedding or Concrete Floor for Loose-housed Pregnant Sows: Consequences for Aggression, Production and Physical Health. Acta Agriculturae Scandinavica, Section A — Animal Science 49, 190–195 (1999).

[35] Tuyttens, F. A. M. The importance of straw for pig and cattle welfare: A review. Applied Animal Behaviour Science 92, 261–282 (2005).

[36] D'Eath, R. B. Repeated locomotion scoring of a sow herd to measure lameness: consistency over time, the effect of sow characteristics and inter-observer reliability. Animal Welfare 21, 219–231 (2012).

[37] Dewey, C. E., Friendship, R. M. & Wilson, M. R. Clinical and postmortem examination of sows culled for lameness. Can Vet J 34, 555–556 (1993).

[38] Kirk, R. K., Svensmark, B., Ellegaard, L. P. & Jensen, H. E. Locomotive Disorders Associated with Sow Mortality in Danish Pig Herds. Journal of Veterinary Medicine Series A 52, 423–428 (2005).

[39] Jensen, T. B., Baadsgaard, N. P., Houe, H., Toft, N. & Østergaard, S. The effect of lameness treatments and treatments for other health disorders on the weight gain and feed conversion in boars at a Danish test station. Livestock Science 112, 34–42 (2007).

[40] Anil, S. S., Anil, L. & Deen, J. Effect of lameness on sow longevity. (2009) doi:10.2460/javma.235.6.734.

[41] Fitzgerald, R. F. et al. The effect of hoof abnormalities on sow behavior and performance. Livestock Science 145, 230–238 (2012).

[42] Heinonen, M., Peltoniemi, O. & Valros, A. Impact of lameness and claw lesions in sows on welfare, health and production. Livestock Science 156, 2–9 (2013).

[43] Nalon, E. et al. Comparison of the inter- and intra-observer repeatability of three gait-scoring scales for sows. Animal 8, 650–659 (2014).

[44] KilBride, A. L., Gillman, C. E. & Green, L. E. A cross-sectional study of prevalence and risk factors for foot lesions and abnormal posture in lactating sows on commercial farms in England. Animal Welfare 19, 473–480 (2010).

[45] Pluym, L. M., Van Nuffel, A., Van Weyenberg, S. & Maes, D. Prevalence of lameness and claw lesions during different stages in thereproductive cycle of sows and the impact on reproduction results. Animal 7, 1174–1181 (2013).

[46] Chapinal, N. et al. Evaluation of welfare and productivity in pregnant sows kept in stalls or in 2 different group housing systems. Journal of Veterinary Behavior 5, 82–93 (2010).

[47] Estienne, M., Harper, A. & Knight, J. Reproductive traits in gilts housed individually or in groups during the fi rst thirty days of gestation. Journal of Swine Health and Production 14, (2006).

[48] Sørensen, J. T., Edwards, S., Noordhuizen, J. & Gunnarsson, S. Animal production systems in the industrialised world. Rev Sci Tech 25, 493–503 (2006).

[49] EMA Committee for Medicinal Products for Veterinary Use (CVMP) and EFSA Panel on Biological Hazards (BIOHAZ) et al. EMA and EFSA Joint Scientific Opinion on measures to reduce the need to use antimicrobial agents in animal husbandry in the European Union, and the resulting impacts on food safety (RONAFA). EFSA Journal 15, e04666 (2017).

[50] Verbrugghe, E. et al. Stress induced Salmonella Typhimurium recrudescence in pigs coincides with cortisol induced increased intracellular proliferation in macrophages. Vet Res 42, 118 (2011).

[51] Cybulski, P., Woźniak, A., Urban, J. & Stadejek, T. Gastric Lesions in Culled Sows: An Underestimated Welfare Issue in Modern Swine Production. Agriculture 11, 927 (2021).

[52] Nielsen, C. L., Kongsted, H., Sørensen, J. T. & Krogh, M. A. Antibiotic and medical zinc oxide usage in Danish conventional and welfare-label pig herds in 2016–2018. Preventive Veterinary Medicine 189, 105283 (2021).

[53] Aarestrup, F. M. The livestock reservoir for antimicrobial resistance: a personal view on changing patterns of risks, effects of interventions and the way forward. Philosophical Transactions of the Royal Society B: Biological Sciences 370, 20140085 (2015).

[54] Scott, A. M. et al. Is antimicrobial administration to food animals a direct threat to human health? A rapid systematic review. International Journal of Antimicrobial Agents 52, 316–323 (2018).

[55] O'Neill, J. ANTIMICROBIALS IN AGRICULTURE AND THE ENVIRONMENT: REDUCING UNNECESSARY USE AND WASTE. THE REVIEW ON ANTIMICROBIAL RESISTANCE. https://edepot.wur.nl/365663 (2015).

[56] EFSA Panel on Animal Health and Welfare (AHAW) et al. African swine fever and outdoor farming of pigs. EFSA Journal 19, e06639 (2021).

[57] Gallardo, M. C. et al. African swine fever: a global view of the current challenge. Porc Health Manag 1, 21 (2015).

[58] Mur, L. et al. Understanding African Swine Fever infection dynamics in Sardinia using a spatially explicit transmission model in domestic pig farms. Transboundary and Emerging Diseases 65, 123–134 (2018).

[59] Authority (EFSA), E. F. S. et al. Risk and protective factors for ASF in domestic pigs and wild boar in the EU, and mitigation measures for managing the disease in wild boar. EFSA Journal 22, e9095 (2024).

[60] EFSA Panel on Animal Health and Welfare (AHAW) et al. Ability of different matrices to transmit African swine fever virus. EFSA Journal 19, e06558 (2021).

[61] Blome, S. et al. Survival of African swine fever virus in feed, bedding materials and mechanical vectors and their potential role in virus transmission. EFSA Supporting Publications 21, 8776E (2024).

[62] Curtis, S. E., Hurst, R. J., Gonyou, H. W., Jensen, A. H. & Muehling, A. J. The Physical Space Requirement of the Sow. Journal of Animal Science 67, 1242–1248 (1989).

[63] Arndt, H., Spindler, B., Hohmeier, S., Hartung, J. & Kemper, N. Planimetric Determination of the Static Space of Cull Sows as the First Step towards a Recommendation of Loading Densities for Cull Sows during Road Transportation in the European Union. Agriculture 11, 20 (2021).

[64] Anil, L., Anil, S. S. & Deen, J. Relationship between postural behaviour and gestation stall dimensions in relation to sow size. Applied Animal Behaviour Science 77, 173–181 (2002).

[65] Stolba, A. & Wood-Gush, D. G. M. The behaviour of pigs in a semi-natural environment. Animal Science 48, 419–425 (1989).

[66] Terlouw, E. M. C., Lawrence, A. B. & Illius, A. W. Influences of feeding level and physical restriction on development of stereotypies in sows. Animal Behaviour 42, 981–991 (1991).

[67] Zhou, Q. et al. Group housing during gestation affects the behaviour of sows and the physiological indices of offspring at weaning. animal 8, 1162–1169 (2014).

[68] Liu, X. et al. A Comparison of the Behavior, Physiology, and Offspring Resilience of Gestating Sows When Raised in a Group Housing System and Individual Stalls. Animals 11, 2076 (2021).

[69] Weng, R. C., Edwards, S. A. & English, P. R. Behaviour, social interactions and lesion scores of group-housed sows in relation to floor space allowance. Applied Animal Behaviour Science 59, 307–316 (1998).

[70] Greenwood, E. C., Plush, K. J., van Wettere, W. H. E. J. & Hughes, P. E. Group and individual sow behavior is altered in early gestation by space allowance in the days immediately following grouping1. Journal of Animal Science 94, 385–393 (2016).

[71] Studnitz, M., Jensen, M. B. & Pedersen, L. J. Why do pigs root and in what will they root?: A review on the exploratory behaviour of pigs in relation to environmental enrichment. Applied Animal Behaviour Science 107, 183–197 (2007).

[72] Durrell, J., Sneddon, I. A. & Beattie, V. E. Effects of Enrichment and Floor Type on Behaviour of Cubicle Loose-Housed Dry Sows. Animal Welfare 6, 297–308 (1997).

[73] Lawrence, A. B. & Terlouw, E. M. C. A review of behavioral factors involved in the development and continued performance of stereotypic behaviors in pigs. Journal of Animal Science 71, 2815–2825 (1993).

[74] Spoolder, H. A. M., Burbidge, J. A., Edwards, S. A., Howard Simmins, P. & Lawrence, A. B. Provision of straw as a foraging substrate reduces the development of excessive chain and bar manipulation in food restricted sows. Applied Animal Behaviour Science 43, 249–262 (1995).

[75] Fraser, D. The effect of straw on the behaviour of sows in tether stalls. Animal Science 21, 59–68 (1975).

[76] Terlouw, E. M. C., Lawrence, A. B. & Illius, A. W. Influences of feeding level and physical restriction on development of stereotypies in sows. Animal Behaviour 42, 981–991 (1991).

[77] Wei, S., Guo, Y. & Yan, P. Comparison of two housing systems on behaviour and performance of fattening pigs. Journal of Applied Animal Research 47, 41–45 (2019).

[78] Fraser, D. The effect of straw on the behaviour of sows in tether stalls. Animal Science 21, 59–68 (1975).

[79] Stewart, C. L., Boyle, L. A. & O'Connell, N. E. The effect of increasing dietary fibre and the provision of straw racks on the welfare of sows housed in small static groups. Animal Welfare 20, 633–640 (2011).

[80] Merlot, E. et al. Improving maternal welfare during gestation has positive outcomes on neonatal survival and modulates offspring immune response in pigs. Physiology & Behavior 249, 113751 (2022).

[81] van de Weerd, H. A. Appropriate Enrichment. Animal Welfare in Practice: Pigs. Camerlink, I., Ed.; 5M Publishing: London, UK. (2019).

[82] Dourmad, J. Y., Etienne, M., Prunier, A. & Noblet, J. The effect of energy and protein intake of sows on their longevity: a review. Livestock Production Science 40, 87–97 (1994).

[83] D'Eath, R. B., Tolkamp, B. J., Kyriazakis, I. & Lawrence, A. B. 'Freedom from hunger' and preventing obesity: the animal welfare implications of reducing food quantity or quality. Animal Behaviour 77, 275–288 (2009).

[84] Meunier-Salaün, M. C., Edwards, S. A. & Robert, S. Effect of dietary fibre on the behaviour and health of the restricted fed sow. Animal Feed Science and Technology 90, 53–69 (2001).

[85] Peltoniemi, O. A., Oliviero, C., Hälli, O. & Heinonen, M. Feeding affects reproductive performance and reproductive endocrinology in the gilt and sow. Acta Vet Scand 49, S6 (2007).

[86] Heinonen, M. et al. Lameness and fertility of sows and gilts in randomly selected loose-housed herds in Finland. Veterinary Record 159, 383–387 (2006).

[87]Grześkowiak, Ł. et al. Dietary fiber and its role in performance, welfare, and health of pigs. Animal Health Research Reviews 23, 165–193 (2022).

[88] Guillemet, R. et al. Dietary fibre for gestating sows: effects on parturition progress, behaviour, litter and sow performance. animal 1, 872–880 (2007).

[89] Spoolder, H. A. M., Geudeke, M. J., Van der Peet-Schwering, C. M. C. & Soede, N. M. Group housing of sows in early pregnancy: A review of success and risk factors. Livestock Science 125, 1–14 (2009).

[90] Kemp, B., Soede, N. M. & Langendijk, P. Effects of boar contact and housing conditions on estrus expression in sows. Theriogenology 63, 643–656 (2005).

[91] Rault, J.-L., Morrison, R. S., Hansen, C. F., Hansen, L. U. & Hemsworth, P. H. Effects of group housing after weaning on sow welfare and sexual behavior1. Journal of Animal Science 92, 5683–5692 (2014).

[92] van Wettere, W. H. E. J., Pain, S. J., Stott, P. G. & Hughes, P. E. Mixing gilts in early pregnancy does not affect embryo survival. Animal Reproduction Science 104, 382–388 (2008).

[93] Verdon, M. et al. Effects of group housing on sow welfare: A review1. Journal of Animal Science 93, 1999–2017 (2015).

[94] Einarsson, S. et al. A 25 years experience of group-housed sows–reproduction in animal welfare-friendly systems. Acta Vet Scand 56, 37 (2014).

[95] Jang, J. C., Hong, J. S., Jin, S. S. & Kim, Y. Y. Comparing gestating sows housing between electronic sow feeding system and a conventional stall over three consecutive parities. Livestock Science 199, 37–45 (2017).

[96] Morgan, L. et al. Effects of group housing on reproductive performance, lameness, injuries and saliva cortisol in gestating sows. Preventive Veterinary Medicine 160, 10–17 (2018).

[97] Min, Y. et al. Comparison of the Productivity of Primiparous Sows Housed in Individual Stalls and Group Housing Systems. Animals 10, 1940 (2020).

[98] Bates, R. O., Edwards, D. B. & Korthals, R. L. Sow performance when housed either in groups with electronic sow feeders or stalls. Livestock Production Science 79, 29–35 (2003).

[99] Morgan, L. et al. Effects of group housing on reproductive performance, lameness, injuries and saliva cortisol in gestating sows. Preventive Veterinary Medicine 160, 10–17 (2018).

[100] Razdan, P. et al. Effect of repeated ACTH-stimulation on early embryonic development and hormonal profiles in sows. Animal Reproduction Science 70, 127–137 (2002).

[101] Razdan, P. et al. Hormonal profiles and embryo survival of sows subjected to induced stress during days 13 and 14 of pregnancy. Animal Reproduction Science 81, 295–312 (2004).

[102] Turner, A. I., Hemsworth, P. H., Canny, B. J. & Tilbrook, A. J. Sustained but Not Repeated Acute Elevation of Cortisol Impaired the Luteinizing Hormone Surge, Estrus, and Ovulation in Gilts1. Biology of Reproduction 61, 614–620 (1999).

[103] Turner, A. I., Hemsworth, P. H. & Tilbrook, A. J. Susceptibility of reproduction in female pigs to impairment by stress and the role of the hypothalamo–pituitary–adrenal axis. Reprod. Fertil. Dev. 14, 377–391 (2002).

[104] Turner, A. I., Hemsworth, P. H. & Tilbrook, A. J. Susceptibility of reproduction in female pigs to impairment by stress or elevation of cortisol. Domestic Animal Endocrinology 29, 398–410 (2005).

[105] Kongsted, A. G. A review of the effect of energy intake on pregnancy rate and litter size–discussed in relation to group-housed non-lactating sows. Livestock Production Science 97, 13–26 (2005).

[106] Kongsted, A. G. Relation between reproduction performance and indicators of feed intake, fear and social stress in commercial herds with group-housed non-lactating sows. Livestock Science 101, 46–56 (2006).

[107] Kongsted, A. G. Stress and fear as possible mediators of reproduction problems in group housed sows: a review. Acta Agriculturae Scandinavica, Section A — Animal Science 54, 58–66 (2004).

[108] Hemsworth, P. H. et al. Effects of group size and floor space allowance on grouped sows: Aggression, stress, skin injuries, and reproductive performance1. Journal of Animal Science 91, 4953–4964 (2013).

[109] Hemsworth, P. H. et al. Effects of varying floor space on aggressive behavior and cortisol concentrations in group-housed sows1. Journal of Animal Science 94, 4809–4818 (2016).

[110] Kay, R. M., Burfoot, A., Spoolder, H. a. M. & Docking, C. M. The effect of flight distance on aggression and skin damage of newly weaned sows at mixing. Proceedings of the British Society of Animal Science 1999, 14–14 (1999).

[111] Barnett, J. L., Cronin, G. M., McCallum, T. H. & Newman, E. A. Effects of pen size/shape and design on aggression when grouping unfamiliar adult pigs. Applied Animal Behaviour Science 36, 111–122 (1993).

[112] Clarke, T., Pluske, J. R., Collins, T., Miller, D. W. & Fleming, P. A. A quantitative and qualitative approach to the assessment of behaviour of sows upon mixing into group pens with or without a partition. Anim. Prod. Sci. 57, 1916–1923 (2016).

[113] Wiegand, R. M., Gonyou, H. W. & Curtis, S. E. Pen shape and size: effects on pig behavior and performance. Applied Animal Behaviour Science 39, 49–61 (1994).

[114] Durrell, J. L., Beattie, V. E., Sneddon, I. A. & Kilpatrick, D. Pre-mixing as a technique for facilitating subgroup formation and reducing sow aggression in large dynamic groups. Applied Animal Behaviour Science 84, 89–99 (2003).

[115] Barnett, J. L., Cronin, G. M., McCallum, T. H. & Newman, E. A. Effects of food and time of day on aggression when grouping unfamiliar adult pigs. Applied Animal Behaviour Science 39, 339–347 (1994).

[116] Whittakera, X., Spoolder, H. a. M., Edwards, S. A., Corning, S. & Lawrence, A. B. The effect of ad libitum feeding of a high fibre diet on the reproductive performance of gilts. Proceedings of the British Society of Animal Science 1996, 146–146 (1996).

[117] Danielsen, V. & Vestergaard, E.-M. Dietary fibre for pregnant sows: effect on performance and behaviour. Animal Feed Science and Technology 90, 71–80 (2001).

[118] Greenwood, E. C., Dickson, C. A. & van Wettere, W. H. E. J. Feeding Strategies Before and at Mixing: The Effect on Sow Aggression and Behavior. Animals 9, 23 (2019).

[119] Murphy, E., Nordquist, R. E. & van der Staay, F. J. A review of behavioural methods to study emotion and mood in pigs, Sus scrofa. Applied Animal Behaviour Science 159, 9–28 (2014).

[120] Moscovice, L. R., Gimsa, U., Otten, W. & Eggert, A. Salivary Cortisol, but Not Oxytocin, Varies With Social Challenges in Domestic Pigs: Implications for Measuring Emotions. Front. Behav. Neurosci. 16, (2022).

[121] Leliveld, L. M. C., Düpjan, S., Tuchscherer, A. & Puppe, B. Behavioural and physiological measures indicate subtle variations in the emotional valence of young pigs. Physiology & Behavior 157, 116–124 (2016).

[122] Pedersen, L. J. Chapter 1 - Overview of commercial pig production systems and their main welfare challenges. in Advances in Pig Welfare (ed. Špinka, M.) 3–25 (Woodhead Publishing, 2018). doi:10.1016/B978-0-08-101012-9.00001-0.

COMPASSION in world farming **Food Business**

Compassion in World Farming is recognised as the leading international farm animal welfare charity. It was founded in 1967 by Peter Roberts, a British dairy farmer who became concerned about the development of modern, intensive factory farming.

Food Business Team
tel +44 (0)1483 521950
email foodbusiness@ciwf.org
www.compassioninfoodbusiness.com

Compassion in World Farming International
River Court
Mill Lane
Godalming
Surrey
GU7 1EZ

Published June 2025.