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'End the cage age': review of technical issues associated with the replacement of farrowing crates for sows and proposals for harmonized legislation

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There is pressure to ban the use of farrowing crates. Without a consensus on acceptable alternative systems, commercial progress is delayed and there are risks of fragmented legislation and building of systems that function less well. There is an urgent need for coherent, effective measures to stimulate forward progress. The main technical points of contention are the allowance of temporary crating and confinement time, pen space, enrichment and flooring. We present a multi-criteria review of these issues, designed to be of use to policymakers and other stakeholders. This review synthesizes the European Food Safety Authority (EFSA) recommendations, the latest scientific evidence base and commercial experience. We discuss potential alternatives and recommend actions for the regulation of close-confinement farrowing and lactation systems. We propose a minimum pen footprint of 6.5m² with linear distances to support unhindered turning by the sow and, when using temporary crating, this should be for no more than 5 days. Flooring type and enrichment provision interact, with regional climatic differences making harmonized legislation about the best options not feasible. The compromises inherent in trying to meet all stakeholder' needs may result in legislation which seemingly only makes a relatively small difference to the welfare of an individual sow and litter, but a large population of animals will benefit, making the overall increase in pig welfare considerable.

KEYWORDS

pigs, confinement time, pen space and dimensions, pen flooring and substrate, free farrowing, temporary crating, loose lactation, legislation

1 Introduction

Confinement farrowing systems which severely restrict the movement of farrowing and lactating sows are a continuing focus for public concern and debate (European Commission, 2023; Vandresen and Hötzel, 2021a, b). Despite policy attention drawn to banning these systems in recent years, for example through campaigns such as the European Citizens' Initiative to 'End the Cage Age' (European Union, 2020; Loeb, 2024) and an acceptance by industry that permanent crating of sows is unsustainable (Baxter et al., 2022; FFL21, 2021), there is little progress in the transition away from farrowing crates. This is, in part, because of a lack of clarity about fundamental issues such as space requirements for new systems, whether temporary crating will be permitted and if permitted, how it would be regulated, as well as issues related to flooring and the provision of enrichment. All these issues affect the cost of an alternative system. Animal science plays an important role in supporting decision making by providing an evidence-base for the animal welfare and performance implications of suitable alternatives. However, despite substantial work in this area (Baxter et al., 2024a; Goumon et al., 2022; EFSA, 2022), stakeholders remain uncertain about committing to design choices and enacting recommendations that might not conform to future legislation. Some of this uncertainty is understandable given the potential negative ramifications of making the wrong choice, but indecision perpetuates the use of crate systems with known animal welfare and health detriments (Baxter et al., 2024a). There is also a pressing issue of a mismatch between the size of conventional farrowing crates and the increasingly large size of sows and their litters (Pedersen et al., 2013). The inability to fully distill the complexity of the substantial evidence-base that exists and to frame implications for the major stakeholders (i.e. societal concerns for the welfare of animals and the environmental impact, the economics for the pig producers and the supply chain) is hampering progress. The aim of this paper is to distill the knowledge from science and practice to make it more accessible and understood by decision makers such that the risks of costly design mistakes are minimized (from both animal welfare and economic points of view) and could ultimately lead to the adoption of common EU legislation which will facilitate the widespread implementation of farrowing pens in which sows can be kept loose.

1.1 Status quo

The use of farrowing crates is already governed differently in different countries. Most European countries still permit use of farrowing crates, and this adheres to the current European Union legislation (Council Directive 2001/93/EC – Council of Europe, 2001), but an increasing minority have enacted or proposed alternative national legislation (Table 1).

2 The need for harmonized legislation

The policy instruments available to improve animal welfare were reviewed some time ago by Ingenbleek et al. (2012) but remain

highly relevant. They categorized these into farmer-based, market-based and government-based instruments and discussed the strengths and weaknesses of each in relation to general improvement of farm animal welfare in the EU. In the context of promoting alternatives to the farrowing crate, instruments such as government subsidies for farms adopting alternative systems are offered by some countries. For example, Denmark has had initiatives since 2013, and, more recently, Finland offered a subsidy of between c.€222 and €277 per sow per year for improved farrowing conditions (i.e. temporary crating) and free farrowing respectively¹. Similar incentives are available in Poland², with farmers offered between c.€183 and €208 per sow per year depending on the welfare improvements they make for farrowing and lactation. Improvements include increases in space (20-50% more than the basic of 3.5m²), providing substrate and late weaning. Such subsidies often prove difficult to access in practice because of associated constraining conditions (e.g. time windows for application, specific systems, low percentage of total costs, increase in building supply costs) and therefore uptake has often been poor. There are also farmer/industry-based initiatives. These include commitments from individual farms/farming companies (e.g. Sunpork³, Australia) and national industry bodies (e.g. Danish Agriculture and Food Council, Denmark⁴; NPA, UK⁵; Inaporc, France⁶). They reflect growing awareness of public opinion and the need for future change or come from perceived market need/opportunity. In relation to market-based initiatives, several farm assurance and label schemes have adopted standards on non-crate farrowing (e.g. Organic EU⁷, UK⁸, RSPCA Assured in the UK⁹, Danish Three Hearts¹⁰, Antonius in Denmark¹¹, Beter Leven in The Netherlands¹²). However, despite these government, industry and market initiatives, the uptake of non-crate systems has been

1 Sikojen ehdot (eläinten hyvinvointikorvauksen sitoumusehdot 2025).

2 <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20230000797> (Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 20 kwietnia 2023 r. w sprawie szczegółowych warunków i szczegółowego trybu przyznawania i wypłaty pomocy finansowej w ramach schematów na rzecz dobrostanu zwierząt w ramach Planu Strategicznego dla Wspólnej Polityki Rolnej na lata 2023-2027 (Title of the regulation: Regulation of the Minister of Agriculture and Rural Development of 20 April 2023).

3 SunPork Launches Revolutionary Farrowing Crate-Free Pork Innovation - Swineweb.com.

4 Vision 2050: Delmålene er klar.

5 NPA publishes position on flexible farrowing - National Pig Association.

6 https://www.leporc.com/assets/e02_a4_rso_demainleporc_210x297_web.pdf.

7 Council Regulation (EC) N° 1804/1999 of 19 July 1999 supplementing Regulation (EEC) N° 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production. 8 Idem, Annex (I)(3) and (V).

8 <https://www.soilassociation.org/>.

9 <https://science.rspca.org.uk/sciencegroup/farmanimals/standards>.

10 Bedre Dyrevelfærd - Fødevarestyrelsen.

11 <https://www.danishcrown.com/da-dk/vores-brands/antonius/om-os/mere-plads-halm-kroelle-paa-halen/>.

12 The Better Life label - Beter Leven keurmerk.

TABLE 1 Enacted and planned regulations for minimum farrowing and lactation standards in countries restricting farrowing crate use.

Country	Date enacted/proposed	Minimum space requirements per sow and litter place	Temporary crating (TC) permitted?	Flooring (F) Nest-building substrate (NBS)
EU Commission Directive 2001/93/EC (of 9 November 2001 amending Directive 91/630/EEC laying down minimum standards for the protection of pigs)	1997	No restrictions on farrowing crate use. 'An unobstructed area behind the sow or gilt must be available for the ease of natural or assisted farrowing' 'Farrowing pens where sows are kept loose must have some means of protecting the piglets, such as farrowing rails'	Farrowing crates permitted	F: General: 'Floors must be smooth but not slippery so as to prevent injury to the pigs and so designed, constructed and maintained as not to cause injury or suffering to pigs. They must be suitable for the size and weight of the pigs and, if no litter is provided, form a rigid, even and stable surface'. 'The lying area must be comfortable, clean and dry.' Piglets: 'A part of the total floor, sufficient to allow the animals to rest together at the same time, must be solid or covered with a mat, or be littered with straw or any other suitable material.' Maximum width of slatted floor openings = 11 mm NBS: 'In the week before the expected farrowing time sows and gilts must be given suitable nesting material in sufficient quantity unless it is not technically feasible for the slurry system used in the establishment'
Austria Tierhaltungsverordnung verlautbart (ThVO), Federal Law Gazette II No. 485/2004; amended by Federal Law Gazette II No. 61/2012	2033 (announced 2010)	≥5.5m ² 'Room for free movement for sow'	Yes. 'Crating only in critical period of piglet's life'	F: 50% lying area with 1/3 solid floor (max. 5 % openings) NBS: Nothing above EU regulations
Denmark Draft executive order on minimum animal welfare requirements for keeping pigs https://hoeringsportalen.dk/Hearing/Details/69168	'From 2023 a ban on permanent fixation of lactating animals is introduced for sows in newly built pig barns as well as a transition period of 15 years for existing barns'.	≥6.5m ² (including area for the piglets) 'The farrow pen must be arranged so that the sow or gilt can turn around unimpeded'.	Yes. 'The freedom of movement of sows and gilts can be restricted by crate in the period from immediately before expected farrowing and up to a maximum of four days after farrowing'.	F: At least 3m ² of the sow's lying area must be solid or drained. NBS: 'In the week before the expected time of farrowing, sows and gilts must have suitable nest building material in sufficient quantity'
Finland Animal Welfare Act 693/2023 https://finlex.fi/fi/lainsaadanto/2023/693 (Chapter 5, section 37)	Building of new farrowing crates banned 2024 Existing crates permitted.	No limitations or regulations on size.	Yes. All new pens must be built for cage free production. Existing farrowing crates can be used until the need of either repairing or rebuilding.	F: All farrowing pens have to be 50% solid or drained. The creep area has to be fully solid. NBS: Nothing above EU regulations
France	2025 'From 2025 all new sheds will need to include cage-free designs for both gestation and farrowing' 2035 'By 2035: 50% of sows in cage-free	No limitations or regulations on size.	Yes	F: Nothing above EU regulations NBS: Nothing above EU regulations

(Continued)

TABLE 1 Continued

Country	Date enacted/proposed	Minimum space requirements per sow and litter place	Temporary crating (TC) permitted?	Flooring (F) Nest-building substrate (NBS)
	buildings for both gestation and farrowing'			
Germany Tierschutz-Nutztierhaltungsverordnung in der Fassung der Bekanntmachung vom 22. August 2006 (BGBl I.S. 2043) die zuletzt durch Artikel 1a der Verordnung vom 29. Januar 2021 (BGBl, I.S. 146) geändert worden ist https://www.gesetze-im-internet.de/tierschnutzv/BjNR275800001.html *Unfallverhütungsvorschrift Tierhaltung https://www.agrarheute.com/media/2021-03/unfallverhuetungsvorschrift-tierhaltung-svlfq.pdf E 1 Ausführungshinweise Schweine, Stand 15.02.2024	2036 (published regulations in 2021) 'buildings that have been approved or been taken into use by 9 February 2021, have a transition period until 9 February 2036 applies'	$\geq 6.5\text{m}^2$ 'A farrowing pen in which the gilt or sow can move freely ... must allow the gilt or sow to turn around without hindrance. A farrowing pen must also be designed so that there is sufficient freedom of movement behind the gilt or sow's lying area for unhindered farrowing and obstetric measures'. 'Farrowing pens must be provided with protective devices to prevent the suckling piglets from being crushed' Minimum pen length = 220cm Note: The area under a raised trough is not considered unlimited usable floor area and thus is not included in the minimum length of 220cm which is a requirement for any crate. Piglet area: 0,033 x average weaning weight 0.66 x average litter size 'The lying area must allow all piglets to rest simultaneously and undisturbed and must be either thermally insulated and heated or covered with suitable bedding'	Yes Length of time: Maximum of 5 days 'Gilts and sows may only be kept in the crate for a maximum period of five days, which includes the time in which the gilt or sow farrows' There is also a statutory requirement within additional regulations for keeping pigs (*Unfallverhütungsvorschrift Tierhaltung - Accident prevention regulation for animal husbandry) that states: 'The operator must ensure that [...] farrowing pens are designed in such a way that no hazards can arise from the mother sow when catching or treating the piglets'	F: '...the lying area for gilts and sows must be designed in such a way that the degree of perforation does not exceed 7%'. Perforated flooring in the lying area of the suckling piglets must be covered. NBS: 'In the week before the expected farrowing date, each gilt or sow must be provided with sufficient straw or other material to satisfy their nest-building behaviour, insofar as this is compatible with the existing facility for faeces and urine disposal according to the state of the art' Note: The reference to the "state of the art" obliges the animal keeper to retrofit or retrofit any available equipment or parts of the system if the manure removal system as a whole thus enables the use of nest building material (see official explanatory memorandum BR-Drucksache 119/06). Thus, at least in new buildings and conversions, the husbandry conditions, especially with regard to soil design and slurry technology, must be designed in such a way that the use of optimally suitable nest building materials such as straw is possible. In existing farms where the use of straw is not compatible with the existing system for faeces and urine disposal, other materials such as jute bags must be made available to the sow. The nest-building material should be offered from the 112th day of pregnancy at the latest and must be constantly available in sufficient quantities at least until the end of the birth process. The nest building material must be able to be taken into the sow's mouth and carried. In the case of crate keeping, it must be ensured that the nest building material is safely accessible for the sow, as unreachable nest building material leads to avoidable excitement.
Sweden (SJVFS 2019:20) Regulations amending the Swedish Board of Agriculture's regulations and general	1987	6.0m^2 (including a creep) with a minimum lying area for the sow of 4.0m^2 .	TC only permitted 'for sows that are aggressive towards their piglets or show abnormal behaviour that presents an obvious risk to the piglets can be	F: Two thirds of the pen should be solid SJVFS 2019:20 See Table 3 (pages 12-13) of the regulations that states '4 out of 6 m^2 should be lying area and not drained'.

(Continued)

TABLE 1 Continued

Country	Date enacted/proposed	Minimum space requirements per sow and litter place	Temporary crating (TC) permitted?	Flooring (F) Nest-building substrate (NBS)
advice (SJVFS 2019:20) on pig farming in agriculture			confined' Length of time: Not stipulated but states 'before farrowing, sows and gilts shall be able to move freely in the farrowing pen, so that they can perform nest building'	NBS: Sows must have access to 'litter that enables them to perform nest-building'
Switzerland Swiss Federal Council. 2008. Animal Protection Ordinance 455.1 (Updated March, 1 st 2018). (Article 50 and annex 1 - Table 3) and Ordinance on keeping of livestock and pets 455.110.1 (Updated March, 1 st 2018). (Article 26).	1997 (with 10 year transition)	'Farrowing pens must be designed in such a way that sows can turn around freely' Built after 2008: 5.5m ² with at least 2.25m ² allocated to the sow lying area. 'a contiguous lying area of at least 1.2m ² with a minimum width of 65cm and a minimum length of 125cm must be in place in the area accessible to the sow. The minimum width of farrowing pen is 150cm. Pens that are narrower than 170cm must not have any installations in the rear 150cm of the pen.' Built before 2008: 4.5m ²	TC only in isolated cases: 'During the parturition phase, sows may be restrained in isolated cases, if they are savaging the piglets or if they have limb problems' Length of time: Only 'during the parturition period' which is defined as 'from the beginning of the nest-building period until the end of the 3 rd day following birth'.	F: 'Of this [<i>the 5.5m² sow lying area</i>] at least 2.25 m ² must be solid floor in the lying area for sow and piglet' NBS: 'Sufficient long straw or other material suitable for nest building must be provided in the pen several days before farrowing and sufficient litter must be provided during the suckling period'. 'Suitable' has to be something that can be carried 'by the snout' not chopped straw, not sawdust but long-straw
Norway Regulations for Keeping Pigs (FOR-2003-02-18-175) Amended by regulation 18 December 2009 no. 1808 (in force 1 January 2010). https://lovdata.no/dokument/SF/forskrift/2003-02-18-175	2000	6.0m ² Width = At least 1.8 m. 'In farrowing pens without restraints, there should be enough space for the sow to lie on a solid floor and turn around easily. 'If a fixation stall [i.e. TC] is used in the farrowing pen, it must have a length measured from the rear edge of the trough of at least 2.00 m, and a width measured internally of 0.70 - 0.80 m, depending on the size of the sows.' (§ 25. Special provisions for sows and gilts)	It is not permitted to restrain pigs (§ 11 Fixation and sampling). However, restraint (i.e. TC*) is permitted if there are: 'particularly restless sows' Length of time: 'from the time of farrowing and up to 7 days after farrowing'. § 25. Special provisions for sows and gilts	F: (General - § 8. Housing – pens, floors, etc.) 'Pigs must have separate lying areas and manure areas, where a small part of the feed trough may be above the manure area. The design of pens must be such that litter can be used. The floor must have a flat, non-slippery surface. There must be a dense floor, deep litter or straw on the lying area, and the area must be large enough for all the animals to lie down at the same time. The rest of the pen may have a draining floor' NBS: 'Ample litter should be used in farrowing pens. Sows should have suitable material to build nests from in the last week before expected farrowing'. 'pigs should have continuous access to an ample amount of materials which they can explore and be occupied. Materials like straw, hay, sawdust, peat and earth can be used' § 25. Special provisions for sows and gilts
New Zealand MPI Discussion Paper 2022/05 (Changes to the Code of Welfare for Pigs and associated regulations NZ Government (mpi.govt.nz)	2025 (announced 2021)	6.5m ² 'The farrowing pen must be at least 6.5m ² in total with 5.0m ² for the sow'. Option A: Free Farrowing 'Accommodation for farrowing and lactating sows must be of suitable design	Under Option B TC is permitted. Length of time: 72h 'If sows are to be confined in farrowing crates: i) they must only be confined after the nesting period; and ii) they must not	F: The flooring in the lying/nesting area must be suitable for containing the nesting material'. NBS: 'The sow must be provided with at least 2kg of long-stemmed straw or an equivalent volume of an alternative substrate with similar properties

(Continued)

TABLE 1 Continued

Country	Date enacted/proposed	Minimum space requirements per sow and litter place	Temporary crating (TC) permitted?	Flooring (F) Nest-building substrate (NBS)
		and sufficient size to allow for separate lying/nesting, dunging and feeding areas'. 'Sows must be able to turn around and lie down at full length and without leg restriction'. Option B: Temporary Crating 'When in a farrowing crate, the sow must be able to avoid all of the following: touching both sides of the crate simultaneously, touching the front and the back of the crate simultaneously, and touching the top of the crate when standing. When not in a farrowing crate, accommodation for farrowing and lactating sows must be of suitable design and sufficient size to allow for separate lying/nesting, dunging and feeding areas. When not in a farrowing crate, the sow must be able to turn around and lie down at full length and without leg restriction.	be confined for longer than 72 hours after completion of nesting behaviour'	(manipulable, destructible, chewable) not less than 48 hours before expected farrowing.

The current EU regulations are presented for reference. The table has been produced based on a combination of published regulations and the authors' knowledge (assisted by colleagues/contacts in different countries) of existing regulations at the time of publication and includes current proposals that may still change.

relatively small at a European level and negligible at an international level. The reasons for this include cost for herd owners (e.g., investment, herd size decrease), competitiveness in external markets, uncertainty regarding future legislation, lack of skilled labor or staff training and concerns about technical performance (NPA⁵; WelFarmers¹³). In such circumstances, the only option to achieve widespread change is the introduction of government-based legislation. As highlighted by Ingenbleek et al. (2012), legislation should set the baseline, above which other market-based instruments can then operate with higher standards if demand exists.

In response to public demand, legislation has already been enacted in some EU member states and has been established in Switzerland and Norway since 1997 and 2000 respectively (Table 1). However, the lack of uniformity in the details of such legislation brings its own problems. Within a Single Market economy, such as the EU, it places individual member states with additional legislation at a competitive disadvantage. Countries with such legislation are mainly those producing for their home market - which is likely to pay a higher price for the product from the farm and is less influenced by the global market, as is the case in Sweden (FFL21, 2021). In contrast, many other countries are exporting to markets, including within the EU, where there is free trade and significant competition - leading to a decline in production if costs are higher in the producing country than for competitors in the market who have lesser legislative requirements. This underlines the importance of common EU-legislation, but of equal importance, is the fact that farmers in countries currently without legislation that goes beyond EU requirements are reluctant to invest in change because of uncertainty about what any future EU-wide legislation might require. This currently represents a major impediment to any EU-wide transition away from farrowing crates. Under such circumstances there is an urgent need to reach common agreement about the formulation of standards/requirements. Finding consensus is challenging as a result of conflict between the different policy objectives of animal welfare, socio-economic and environmental interests (e.g. Potori et al., 2023; European Commission 2022¹⁴; Moustsen et al., 2023) and multi-criteria assessment is therefore essential (Ruckli et al., 2022; Olsen et al., 2023). The main issues under debate are confinement time for the sow, space and design requirements for the farrowing pen and the linked issues of flooring and nest-building substrate/enrichment provision. Here we review the current arguments on each of these issues and propose a compromise which might form the basis for common legislation. We take the EFSA (2022) recommendations on each of these 'sticking points' as our starting point, then distill the scientific evidence on each issue, including any new scientific evidence published since the EFSA opinion (2022). We then present industry perspectives based on the response of Copa-Cegeca (Potori et al., 2023) to the EFSA report, other published field trials and

industry opinions (e.g. NPA⁵, WelFarmers¹³) and *ad hoc* conversations with commercial producers in different countries.

2.1 Confinement time

EFSA (2022) concluded that although piglet mortality is substantially higher if the sow is never confined, 'a temporary crating system with an average space for the sow of 4.3–6.3m² can achieve the same piglet survival as a permanent crating system. The minimum confinement time of a sow in a temporary crating system to achieve this is 7 days after farrowing (90% certainty range between 3.4 and 16 days)'.

2.1.1 Latest evidence base and commercial experience

Whilst 'End the Cage Age' proposals would require zero confinement for the sow, current scientific evidence suggests that this would result in an increase in neonatal piglet mortality. A compromise therefore exists between the welfare of the sow and her piglets. There are also practical implications regarding the welfare of the stockpersons, as many critical tasks must be carried out in the periparturient period when the sow can be aggressive in protecting her piglets (Marchant, 2002). For these reasons, a compromise allowing the use of temporary confinement of the sow, if necessary, seems appropriate (Baxter et al., 2022).

Several large-scale studies show that in a well-designed system, 4 days post-farrowing is an adequate confinement period (e.g. Moustsen et al., 2013; Heidinger et al., 2018). Confinement for longer periods reduces the sow's ability to increase her activity, increases stress (Cronin et al., 1991; Jarvis et al., 2006) and reduces the benefits to piglets of easier udder access which explains the higher weaning weights reported in loose systems (e.g. Pedersen et al., 2011; Chidgey et al., 2015; Nowland et al., 2019).

The time at which the sow is initially confined also has welfare and practical implications. The greatest activity of the sow occurs shortly prior to farrowing, during the nest-site seeking and nest building phases. In studies of sows kept under semi-natural conditions, Jensen (1986) observed expectant sows leaving the rest of the herd 2.5–2 days before farrowing, travelling 2.5–6.5km, stopping to build mock-nests before choosing a secluded nest-site and switching to the more intensive business of constructing the final nest in the last 24h before farrowing. This more intensive building phase involves, rooting, gathering, carrying and arranging substrates and has received much research attention (Algers and Uvnäs-Moberg, 2007; Wischner et al., 2009; Yun and Valros, 2015) in both crates and pen systems where it is readily performed with different degrees of satisfaction. This increase in activity is hormonally triggered and ceases via a combination of external and internal cues (sensation of a formed nest against the udder and increased oxytocin) (Algers and Uvnäs-Moberg, 2007). The ambulatory and building phases of nesting are considered a behavioural need, which if thwarted results in a negative welfare state, and if fulfilled has positive impacts on parturient maternal behaviour (Rosvold et al., 2019). The natural changes in sow

13 WelFarmers webinar: Our dedication stands in respecting pigs (see at 30:09 (mm:ss)).

14 European Commission 2022. Meeting of the sub-group on the welfare of pigs.

behaviour and physiology that prepare them for farrowing support the recommendation to move sows into their farrowing accommodation at least 3–5 days prior to their due date and keep them loose with access to nesting substrate. There is also evidence that late entry to the farrowing accommodation can have a negative impact on piglet survival and sow health. Baxter et al. (2024b) followed over 3000 farrowings in commercial herds operating free farrowing facilities and found an increase in piglet mortality if moving sows into farrowing accommodation later than three days from their due date. There is also some evidence of a negative impact on sow health, with late movement (less than 4 days relative to the sow's due date) associated with an increased risk of postpartum dysgalactia syndrome (Papadopoulos et al., 2010). Based on this evidence we recommend that sows and gilts be moved into farrowing accommodation no later than 3 days before their due date and ideally no later than 5 days before. This recommendation gives some flexibility for variation in gestation length and batch management. We also recommend that sows initially be kept loose so that they can realize the benefits of increased ambulation and perform highly motivated and functional nesting activities in advance of farrowing.

Any confinement during the nesting phase is detrimental to the sow. However, if there is a necessity to confine the sow a compromise could be to allow her to initially be loose in the pen and to only confine her shortly prior to farrowing (i.e. no more than 24h). This would at least allow for the ambulatory phase of nest-building and offers a compromise between behavioural freedom for the sow whilst reducing the risk that she would crush any piglets born whilst she still has unrestricted movement (Goumon et al., 2022).

If legislation is to permit a period of temporary confinement for the sow, either as a long term or transitional measure, this can be achieved in two ways. Within a conventional farrowing pen, the sides of the farrowing crate can be removed or opened (often referred to as a temporary crating or an adaptive/flexible farrowing system). Alternatively, within a pen designed to be suitable for free farrowing and lactation a temporary confinement structure can be utilised and thereafter removed. EFSA (2022) emphasize that 'the use of temporary farrowing crate systems cannot be advised as a step in a farm's transition from farrowing crates to farrowing pens, unless the size of the temporary farrowing crate system is the same as that of the future free farrowing pen'. This indicates that the pen design criteria for future buildings should be based on the requirements for free farrowing, even if some temporary confinement structure is included in the first instance. Thus, we recommend a transition system in which a pen designed for a loose sow, with a means of optional confinement, is used rather than using a farrowing crate (within a smaller pen) with the possibility of being opened.

2.2 Pen space and dimensions

Based on allometric modelling, EFSA (2022) concluded that the minimum space required for a sow of 250kg liveweight, with a body length of c.1.85m, to establish functional areas in an unpartitioned pen is 4.92m². This assumes that the functional areas for feeding,

nesting/resting and dunging do not overlap spatially. However, in a pen with partitions between functional areas this space increases to 6.84m², and to allow the sow to express locomotory activity substantially more space is needed (>22m²).

When also considering the piglets' needs, EFSA (2022) concluded that 'reducing the space available to the lactating sow below 6.6m² will reduce her freedom of movement and increase the mortality of her piglets. Above 6.6m², the behavioural freedom of sows and piglets is increased, but piglet mortality does not further improve'. With the additional allowance of 1.2m² for a separated piglet creep area, this indicates a minimum total pen size of 7.8m².

2.2.1 Latest evidence base and commercial experience

It is crucial to consider information from practical experience. This was instrumental in informing legislative changes in Sweden¹⁵, albeit to withdraw a requirement for having a minimum 200 cm circle for sows to turn (Hedman, 2020). Decisions on every aspect of the pen affect the overall pen dimensions and thus the required size of new buildings or possible herd size if existing buildings are converted. Therefore, it is important to accommodate individual producer discretion with the proviso that they adhere to the minimum legislative requirements. Any legal regulation should be considered the minimum space required and individual pig producers and/or markets can decide to increase space beyond this.

The EFSA-recommendation of 6.6m² for the sow was associated with a wide confidence interval of 4.5–9.8m² (+1.2m² for the piglet area). The wide range of the available knowledge at the time of the EFSA review does not unambiguously support a specific pen-size. It is noted that the minimum area as proposed by EFSA (2022) is also greater than currently specified in legislation for some member states (Austria 5.5m²; Sweden 6.0m² and Germany 6.5m²) (Table 1). EFSA mentions that each additional square meter of available space is associated with a predicted increase in locomotory behaviour of 0.3% (= 4 min per 24 h). However, it can be argued that differences in daily management, genetics, frequency of feed delivery per day and barn activity influence the locomotory behaviour by more than 4 minutes per 24h.

Whilst an increase in space allowance *might* increase sows' locomotory behaviour, an increase in space *will* increase investment costs and the environmental emissions. In Denmark, the cost per m² of pen was estimated at Dkr. 4,000 (c.537€) for a loose lactating sow (Ministeriet for Fødevarer, Landbrug og Fiskeri (Ministry of Food, A. and F., 2022)). Because farrowing pens for loose sows are approximately 30% larger than farrowing crates, the cost per pen is 30% higher than the cost for a farrowing crate at the time. In the UK, the latest estimate for building any new farrowing place is thought to be in the range of £5,000 to £8,000 (c.5966–9550€), double that of retrofitting an existing building (Gooding et al., 2025). Malak-Rawlikowska et al. (2024) estimated the total selected costs per piglet weaned (selected variable costs and depreciation of new investments plus existing buildings) for EU-27 (EUR/piglet) to increase by 31–50% depending on the specific farm circumstance.

¹⁵ <https://lagen.nu/sjvfs/2019:14>.

The complexity of deciding the minimum space allowance for pens for loose lactating sows led SEGES to ask experts in pig welfare and with experience of loose housing of lactating sows, to engage in a theoretical exercise. Eight surveyed experts assessed the functionality of farrowing pens with similar layout, but with varying space allowance (5.5, 6.0, 6.5, 7.0, 7.8 m²), pen dimensions and floor profiles (Moustsen and Nielsen, 2024). The experts more often assessed that at space allowances below 6.5m² sows and/or piglets were limited in performing behavioural elements. On the other hand, the experts assessed that the possibilities of the sows and piglets changed very little at areas of 7m² and above. Similarly, the shape of the pens and the design of the floor were important for pen areas of 6.5m² or less, but not for larger pen areas. This may be related to the fact that, in the survey, rectangular pens with an area of $\geq 6.5\text{m}^2$ all had a depth of at least 3.0m and a width of at least 2.1m. Thus, there were no pen-sides that were shorter than the length of a sow and thus no dimensions that might limit sow movement.

It might appear logical that, to ensure sows have the option to turn unhindered as required for the performance of nest building and piglet gathering behaviours, there should be a clear turning circle within a pen with the diameter of at least the length of the sow. Considering that pen dimensions do not change according to which sow enters the pen, they should accommodate at least the 95th percentile of full-grown sows. In a recent experiment, Moustsen et al. (2025 under review)¹⁶ investigated the turning behaviour of young and full-grown sows in pens which varied in dimension. Their results showed that for sows in late gestation to be able to turn unhindered, a minimum unobstructed pen width of only 160cm was necessary. However, greater distances are required in other pen dimensions. Such dimensions, which can have different orientations within the pen, include a lying area which should be a sow length plus 50 cm to allow posture changes (Moustsen and Duus, 2006), and a distance behind the feed trough and in the dunging area of at least the length of the biggest sow (e.g. 206cm) or length of parity 5 or older (95th percentile averaged 203cm) (Nielsen et al., 2018). However, these distances can be on a diagonal within the pen. Furthermore, there should be space perpendicular to the sow lying axis which permits suckling to take place throughout lactation. This needs to, at least, equal the body depth of the sow (spine to teat) plus the body length of the piglets up to four weeks of age (measured in Danish sows as 71 + 55 = 126cm; Moustsen and Nielsen, 2017; Nielsen et al., 2018) and must be unobstructed up to at least the height of the lying sow and standing piglets.

The survey work by Moustsen and Nielsen (2024) led to the development of a decision support tool consisting of 'paper pigs', a sow and associated piglets in the scale 1:10 to visualize animals in

different pen designs, and an associated checklist¹⁷. The checklist asks questions about the function of the farrowing pen whilst the sow is loose and whilst temporarily confined, as well as about needs of the piglets, staff and the environment. For all questions, there is an accompanying explanation of why this feature is important. There is considerable demand for the tool from pig producers, consultants, equipment suppliers and other stakeholders since its launch, an indication of industry appetite for transitioning away from crates. The checklist illustrates the importance of different functional areas and pen dimensions for the functionality of the farrowing pens and thus strengthens the basis for decision-making.

Current EU regulations do not specify a minimum area for piglets (Table 1), but state that all piglets should be able to lie on solid flooring up to weaning. Suitable equations to calculate the solid area are found in the EFSA opinion (2022). They suggest the area should be no less than 1.2m². Whilst this is higher than some recommendations (e.g., Fels et al., 2016 - suggests 0.90m² for 14 piglets up to 3-weeks old), it is lower than others (e.g., Wheeler et al., 2008 concludes that 1.3m² would accommodate the heaviest litter of 10 piglets from an animal comfort perspective). All young piglets, even in the largest litters, should be able to lie together in a heated area. For example, the space occupied by a litter of 16, 7-day old piglets can be estimated as 0.8m² (Moustsen and Nielsen, 2017). EFSA does not specify that all the 1.2m² piglet-area is in the heated creep, which affords some license to use non-creep space inaccessible to the sow to achieve this recommendation (e.g. space under rails or sloped walls). Having extra piglet-only space affords room for supplementary feeding and additional management procedures that might be necessary with large litters (e.g. split suckling). As the piglets age and become more robust they can also share space with the sow.

2.3 Pen flooring and substrate/enrichment

2.3.1 Flooring

Given the considerable size, behavioural, and developmental variation between sows and piglets, reconciling their flooring needs is difficult and there is little research on this topic (EFSA, 2005). The 2005 EFSA Scientific Opinion provides general detail on the requirements of flooring for weaners and rearing pigs, and the associated consequences for pig welfare were summarized by EFSA in the 2022 Scientific Opinion (section 7.7.3. Types of flooring pg. 234). Many of these are also relevant to sows and piglets but EFSA (2022) did not make specific recommendations for flooring in the farrowing accommodation. However, they stated a preference in the general body of the Opinion for 'solid floors instead of part-concrete, part round-weld-mesh flooring' to address limb and foot injuries in farrowing accommodation. Consideration of the flooring in farrowing pens is vital from the perspectives of hygiene, thermal and physical comfort for both sows and piglets, and the provision of substrates, not only for nest-building activities but for foraging opportunities for the sow and her

16 Moustsen, V. A., Baxter, E. M., Boldsen, S. K., Nielsen, M. B. F., and Edwards, S. A. (2025). Sows turned unhindered at less than their own body length - Implications for farrowing pen design. *Front. Anim. Sci.* in review.

17 Paper pigs and checklist help you to better barn design - SEGES TV.

piglets thereafter. We will consider the first three of these in terms of the scientific evidence on animal welfare, knowledge on the environmental impact and operational efficiency gleaned from farming practice. The implications of flooring for provision of enrichment and nest-building substrates will be discussed later in relation to the nature of the substrates provided.

2.3.1.1 Latest evidence base and commercial experience

Solid flooring is often advocated for improving animal welfare because it enables provision of deep bedding (e.g., Tuytens, 2005). This provides cushioning and therefore physical comfort to sows (Baxter et al., 2011) and also reduces the risk of injuries and abrasions to the skin and claws of both sows and piglets. However, for numerous reasons relating to the need to reduce production costs, the pig industry moved away from the provision of bedding decades ago - apart from in niche 'high-welfare' production systems - and this trend is unlikely to be reversed. Many of the animal welfare advantages of solid flooring are negated if bedding is not used, or is used in insufficient quantities, as urine and faeces readily accumulate on solid floors. For example, a Danish Scheme (Miljø- og Fødevareministeriet / Årsrapport, 2018) required solid floor in the sow area but found that, even with 5% drainage slots, pen hygiene deteriorated, leading to a change in the scheme to allow for slatted flooring. Soiled floors can be slippery such that sows are less willing to move around, and piglets are at increased risk of injury from sows losing stability when changing posture (Baxter et al., 2011). Dirty conditions also pose a risk of hypothermia to piglets and a major disease risk, making cleanliness the pig industry's major requirement for flooring in farrowing accommodation. A higher proportion of slatted flooring is considered beneficial as this requires less labor for cleaning and maintenance (Mousten et al., 2023).

Whilst there are reports of bare (unbedded) solid concrete floors causing injury to pigs (EFSA, 2022), higher proportions of slatted flooring and lower quantities of bedding are more generally associated with a greater risk of wounds on sows and piglets' limbs and hooves (e.g. Mouttoutu et al., 1999; Kilbride et al., 2009; EFSA, 2022). EFSA (2022) stated that there should be 'provision of mats or a substrate such as straw' to address such injuries in the farrowing accommodation. Notwithstanding the obvious benefits to animal welfare there are numerous reasons, including cost and cleanliness as discussed above, why either of these options are unlikely to be used in practice. However, not all commercially available slatted floors are equal. For example, plastic slatted floors can be slippery when wet and cause sows to injure their limbs due to falls (Singh et al., 2017). In several reports, the most injurious flooring to sow and piglets' skin and hooves was slatted steel (a.k.a. tribar), whilst cast iron and plastic-coated expanded metal were the least injurious to sows' limbs (Lewis et al., 2005; Boyle and Lewis, 2010; Calderón Díaz et al., 2014). Sows on the latter floor also showed the shortest latency to lie down on first introduction to a farrowing crate and had the shortest stand-to-lying transition times. Furthermore, plastic-coated metal flooring is consistently preferred by piglets over other types of slatted floors (Pouteaux et al., 1983; Farmer and Christison, 1982; Lewis et al., 2005).

High quality plastic-coated slatted floors may be welfare-friendly for use in farrowing pens and offer the added benefit of good hygiene

and therefore reduced labor and disease risk. Nevertheless, pens for farrowing and lactating sows and their piglets still need to include some area of solid floor, at a minimum for the piglet creep area. However, whilst some welfare recommendations (e.g. Sweden, see Table 1) for farrowing pens state that the lying area for lactating sows should be two thirds solid, it is not feasible to prescribe a specific amount of solid flooring given the variety of influencing factors. These include 1) pen shape/size, 2) slurry management and 3) substrate choice (discussed later). How well a portion of solid flooring 'functions' above ground in terms of cleanliness is largely dependent on overall pen size. For example, a recommendation of two-thirds solid in a 6.5m² pen is problematic, particularly if the pen-shape is square. This is because the sow is unable to delineate a section of the pen as a distinct functional dunging area (Mousten et al., 2023). In a larger pen, a solid area equivalent to one-third of the floor area would be correspondingly larger and therefore more likely to function properly as a place for the sow to lie. Slurry management is a growing area of concern because of the need to consider environmental requirements in decisions about flooring. Whilst slatted materials help ensure clean floor surfaces, they increase surface exposure of the liquid slurry underneath to the air, resulting in greater gaseous emission. Recent innovations in slurry management stemming from concerns about ammonia emissions (Pérez, 2024) mean that it is possible to include partially or fully slatted flooring in pens and simultaneously minimize ammonia emissions (Grønberg et al., 2025). It is likely that such innovations would also offer benefits to pig welfare in terms of better respiratory health (Pessoa et al., 2022).

2.3.2 Substrate provision

When considering the provision of enrichment material in farrowing pens, EFSA (2022) highlighted the different functions that such material should serve. Greatest emphasis was given to its role as a nest-building substrate, but they also recommended that sows and piglets should be provided with enrichment material that allows them to perform exploratory behaviour in the period from farrowing to weaning.

There is clear evidence that nest building is an endogenously motivated behavioural need in the period shortly prior to parturition (Algers and Uvnäs-Moberg, 2007). When considering different nest building materials, EFSA (2022) concluded that the available scientific evidence did not permit ranking of different nest-building materials unambiguously with regard to their positive effect. A semi-quantitative assessment of the extent to which different materials could satisfy the functional behavioural elements of nest-building behaviour was conducted. It was concluded that a deep floor layer of long-structured material, such as long-cut straw or hay, enabled performance of a variety of functional behavioural elements of nest-building and should be provided at least on the day before farrowing. However, provision of such material poses several challenges, not least that a considerable portion of the pen would need to be solid flooring, with the adverse effects on hygiene, biosecurity and the environment. Providing such amounts of substrate also has cost and practicality implications. The

provision of a lesser amount of such material, such as might be provided in a rack was the next highest scored option (EFSA, 2022). This provision would still likely require a portion of solid floor, large enough to cover the area under the rack and thereby trap fallen substrate and is not without cost and practicality considerations. The suggested practical alternative of a jute sack was scored as less suitable by EFSA (2022), as it cannot fully satisfy all functional nest building behaviours.

EFSA (2022) highlighted the need for enrichment to meet both the sow and piglets' behavioural needs for foraging and exploration throughout the lactation period. They concluded that whilst such provision was important, the limited scientific evidence for this stage of production did not allow for determination of any specific enrichment materials. It is reasonable to assume that lactating sows and piglets prefer the same enrichment material characteristics as other pig categories; i.e. edible organic materials and straw are better than destructible point-source materials provided loose on the floor or fixed on the pen walls (e.g. fresh wood, hessian sacks, jute ropes), whilst non-edible point-source enrichment-objects made of plastic or metal are least effective.

2.3.2.1 Latest evidence base and commercial experience

Industry has major concerns about substrate provision for a variety of reasons, including purchasing cost and the practicality and labor cost of regularly cleaning and replenishing the materials. Biosecurity and the risk of diseases such as African Swine Fever and Salmonella are also commonly mentioned in relation to organic substrate provision. EFSA does not reach specific conclusions regarding such risks but stresses the importance of using uncontaminated straw to prevent mycotoxin exposure (EFSA, 2022). It can be difficult in many countries to source high-quality, contaminant-free straw, an issue that could be exacerbated by changing climatic conditions. Ongoing research¹⁸ is investigating a range of alternative substrates such as haylage or hay provided in racks to sows in farrowing crates, but this can become knotted around fittings in the pen and out of reach of a crated sow and pose a risk to pen hygiene. Recently, a soluble, biodegradable biopolymer-based material, structurally resembling natural fiber and provided to sows in crates showed promise (reducing farrowing duration) (Monteiro et al., 2025).

Following early work by Bolhuis et al. (2018) on alternative nesting materials including jute sacks, more recent behavioural studies confirm their benefit in terms of a general reduction in behaviour directed to the fixtures and fittings (crate, floor etc.) by sows in crates but show little or no impact on the farrowing process (e.g. duration) (Plush et al., 2021; Markland et al., 2023; Hukkinen et al., 2024). Meanwhile, a meta-analysis of 26 studies involving natural fiber, man-made materials (e.g., hessian, jute, or burlap sacks) demonstrated their association with a tendency for lower stillbirth rates (Monteiro et al., 2023). This included a large study involving >600 sows, where Fynn et al. (2021) found a lower percentage of stillbirths when sows had access to burlap sheets prior to farrowing. In most of these studies, sacks were compared to other point source or easily applicable forms of nesting enrichment and

not to large quantities of nesting material (e.g. straw) at ground level, although Hukkinen et al. (2024) found that crated sows used jute and a small amount of straw (1 liter x 2/day) equally. Markland et al. (2023) concluded that jute fabric was probably insufficient to satisfy the nest-building needs of sows. In addition, Plush et al. (2021) found sows with jute fabric bite it more aggressively than straw, which they suggested was due to the sow's frustration at being unable to move the jute fabric to the desired location, and their conclusion was that only straw positively affected sow welfare in the crated farrowing system.

For enrichment provision to pigs in general, the industry generally uses point source, inedible and therefore durable materials, though natural fiber (hessian, jute or burlap) sacks and ropes (sisal or hemp) might be an acceptable compromise (AHDB¹⁹). However, research is generally still lacking on sow and piglet enrichment use during the lactation period. Valros et al. (2017) reported almost non-existent use of a wooden enrichment device during the first weeks after farrowing by sows in a farrowing crate. They discuss that this could be because sows do not use wood much during lactation or that other motivations might be of higher priority at this stage, such as those related to piglet care and nursing. Alternatively sows likely have a strong need to rest following farrowing given evidence of high levels of lying and generally low activity levels during the beginning of lactation, with an increase after the second week postpartum (Valros et al., 2003; Lambertz et al., 2015). This could suggest that sows need for enrichment post-farrowing and particularly during the first two weeks of lactation could be met by point source enrichment in the form of a hanging natural fiber sack or rope or minimal amount of organic substrate provided in a rack.

EFSA (2022) summarized both the immediate and longer-term benefits of enrichment for suckling piglets, which is reinforced by more recent evidence for the benefits of positive behaviours such as play/interaction with enrichment on piglet immune function and health (Steinerová et al., 2024). When considering enrichment for piglets, early studies generally used substrates like straw, shavings or shredded paper (Vanheukelom et al., 2012) and few studies have compared different types of enrichment for suckling piglets, particularly those that might be compatible with a (part-) slatted farrowing pen. In a comparison of 10 varied enrichment items, presented for a 5 day period to 3-week old litters of piglets (Docking et al., 2008), all objects received only limited attention on the first day of presentation (<500 sec/12h, with compost most used) and only novel items (replenished compost and an ice block) still attracted any significant use after 4 days. Unchanging suspended objects (rubber ball, chain, string), objects fastened to the pen wall (brush-head, carpet piece) or placed at floor level (boot, metal weight) were largely ignored. Lewis et al. (2006) found that piglets observed on days 14, 18, 22 and 26 after farrowing spent significantly more time interacting with shredded newspaper presented in two boxes than with two natural fiber ropes (length 1 m), whilst Telkänranta et al. (2014) reported that a daily sheet of newspaper and 10 pieces of hanging sisal rope elicited more enrichment-directed activity in suckling piglets than a suspended commercial toy ball. More recently, although not reporting detailed behavioural observations, Fynn et al. (2021) and Scott et al. (2024) suggested that burlap sheets

18 <https://www.teagasc.ie/animals/pigs/research/research-projects/onenewpig-project/project-tasks> (number 8).

19 <https://ahdb.org.uk/knowledge-library/environmental-enrichment-for-pigs>.

hung onto farrowing crates seemed to be valued enrichment for piglets as well as sows. Schmitt et al. (2020) showed a clear and growing preference, from d1 to d14 of lactation, for hessian sheets rather than bamboo rods and noted that usage was greater when these objects were suspended in the middle of the pen rather than attached to the pen wall. Attaching foraging-stimulating enrichment (canvas cloths, cotton ropes and PVC spiral tubes) to the creep feeder also beneficially increased attraction to a 'play-feeder' (Middelkoop et al., 2019).

As previously mentioned, the choice of enrichment substrate needs to be considered in relation to decisions on the proportion of solid flooring required in pens. If substrates recommended as optimal by EFSA (2022), such as straw provided at ground level, are to be used as enrichment a greater proportion of solid flooring is required. However, if substrates are provided in a rack obviously the portion of solid floor required can be smaller. Arguably it is less of a concern if soluble natural fiber-like substrates such as tested by Monteiro et al. (2025) are provided in a rack over slatted floor as the substrate does not interfere with slurry management. Nevertheless, loss of substrate between the slats represents a significant waste when it could be used by the pigs. Rack design and placement are also important considerations as this has an important role to play in the degree to which pigs can access/extract substrates. Hay is difficult for sows to extract from racks, even with generous opening spaces (anecdotal evidence/pers comm Melissa Cupido). If rack openings are too small, even short, chopped substrate particles are difficult for sows to extract and obviously if racks are set too high, sows cannot reach them. Furthermore, providing substrates to sows in racks either for nesting or for exploratory purposes during lactation means that the substrate is not immediately accessible by the piglets, apart from what falls to the (ideally solid) floor.

Because it seems unlikely that straw or other organic substrates will be the nesting/enrichment substrate of choice in many countries, both inside and out of Europe, for the reasons discussed previously, provision of natural fiber (hessian, jute or burlap) sheets/sacks and ropes (sisal or hemp) might be an acceptable compromise. These provide a range of behavioural benefits and are operable even in fully slatted pens, although special care will be needed to ensure they remain accessible for piglets throughout lactation. Clearly there is great need for innovations in enrichment provision to sows and piglets in farrowing pens.

3 Actionable recommendations for harmonized legislation

- We propose that all new farrowing accommodation should be designed with the possibility to accommodate sows loose during farrowing and lactation.
- We propose that, if necessary, temporary crating be permitted between 1 day prior to expected farrowing and 4 days after farrowing to balance the needs of the sow, the piglets and the stockpeople. This provides an 'insurance policy' which will encourage farmers to take the first step towards the ideal situation of a non-crate (i.e. free farrowing) system in the future, where those who have tried and gained management

experience and confidence can further reduce confinement time. Sows and gilts should be moved into their farrowing accommodation loose and this should be at least 3 days before their expected farrowing date.

- We propose that the minimum pen size should be 6.5m^2 to permit essential functional behaviours, with a minimum length of 250cm in at least one dimension to accommodate lying and posture changes by the sow and an unobstructed turning width of at least 160 cm perpendicular to this. These recommendations should be considered an absolute minimum and, if litter size continues to increase and/or weaning age is later, it will be necessary to have a larger pen. We propose that within this 6.5m^2 pen, there is a 1.2m^2 minimum lying area for the piglets which is inaccessible to the sow.
- We propose that all sows should be provided with a nest-building substrate from 48h prior to expected farrowing, and this should be at an absolute minimum a jute sack/sheet or an easily extractable substrate from a rack, and ideally particulate material at floor level. During other periods from entry to the farrowing pen until weaning, enrichment should be continuously available for both sow and piglets which is destructible and organic, e.g. particulate substrate or a jute sack/sheet.
- We propose that pens must include a portion of solid flooring - at a minimum to facilitate a comfortable and safe creep area for the piglets and for underneath racks to retain substrate used for enrichment. Thereafter decisions on the amount of solid floor should be based on pen size and shape, slurry management and the choice of substrate. Where floors are slatted in the sow lying area, use of plastic-coated metal floors is encouraged.

4 Considerations in the implementation of future legislation

Several herd owners built farrowing pens for loose lactating sows in commercial herds, despite no legal requirement, significantly aiding their development and implementation. Hence, they incurred considerable financial risk given the absence of legal design requirements and that buildings have a lifespan of approximately 30 years. This readiness to innovate made their facilities available so that it was possible to carry out trials under commercial conditions. This has been crucial to the ongoing development of recommendations for the design of farrowing pens for loose sows. Herd owners converted their farrowing accommodation based on the best available knowledge at the time. Some of the farrowing pens for loose sows were established with regard to the specifications of a subsidy scheme available at that time. It is worth noting that none of these schemes had a minimum area of 6.5m^2 , and as such, the majority of pens were installed below 6.5m^2 . This must also be seen in light of the fact that a farrowing pen for loose sows is complex, and different pens with

different dimensions can meet the needs of the sow, the piglets and the staff. This also means that the existing farrowing pens for loose sows meet a lot of needs, although no pen – existing or new – can meet all needs. Policymakers should acknowledge the contribution of the early adopters rather than penalize them for elements of design which differ from subsequent requirements.

In the implementation of new legislation, some farms will seek to retrofit their existing farrowing crate accommodation. This poses many challenges because of the need for greater space per pen and the likelihood of mismatches in floor profiling and manure management structures. Fewer sows will be accommodated within existing building structures, meaning that farms will have to reduce sow herd size and face potential imbalances in provision of accommodation at the different production stages. Because of such difficulties in converting existing buildings, it is likely that many farms will see building new farrowing and lactation facilities as the best solution. Whilst this will facilitate the construction of pens with optimized design, it will also involve potentially complex and time-consuming planning requirements. To promote a rapid transition from crate housing, policy makers should find ways to mitigate the planning difficulties frequently experienced in this process.

If new legislation is enacted, careful consideration should be given to the implications for trade. To ensure harmonization across Member States, the future EU legislative framework should adopt more prescriptive language to ensure consistency in implementation. Whilst harmonized legislation within the EU will remove any trade frictions within the Single Market, exports from the EU to third countries could be compromised by higher production costs, whilst the domestic market may face a challenge from lower cost imports into the EU of products produced elsewhere. Trade agreements with partner countries should seek to minimize the risk that import of meat that does not comply with the same EU animal welfare requirements could displace domestic production (Molitorisová and Burke, 2023). Identifying a policy design compatible with the EU's trade commitments is essential to avoid placing the EU in a legally vulnerable position. In this way, EU legislation could contribute to the improvement of pig welfare in third countries by setting an example and creating a market for products from animals reared according to improved welfare standards. The size and influence of the EU market means its import conditions can incentivize third-country producers or governments to align their practices with EU standards in order to gain or maintain market access.

Any future legislation will inevitably involve some compromise to balance the conflicting needs of animal welfare, environmental impact and economics. Such compromise legislation should leave room for development of future sow lactation housing in *the least harmful way*, minimizing detrimental effects to the industry if further changes are required by society in the future. Legislation provides the baseline for the industry and does not preclude that other policy options advance the situation.

5 Conclusions

When contemplating replacement of the farrowing crate by an alternative system, as required by the 'End the Cage Age' European

Citizens' Initiative, there are many conflicts between the ideal provision for animal welfare and considerations of practicality, economic and environmental interests. Unless all stakeholders can accept some compromises, progress regarding the improvement of animal welfare will remain stalled. If the changes are insufficient it will perpetuate compromised sow (and piglet) welfare in farrowing accommodation. Nevertheless, if the changes are too great and too fast and without some public financial support the EU pig industry will suffer. Further delay on an agreed way forward risks asymmetric development of regulations and could lead to tensions between producers across the EU member states.

As well as the many challenges associated with changes within the farrowing system, there is great potential for positive outcomes in terms of improved sow welfare and more robust and resilient piglets. Whilst systems with reduced confinement place greater demands on stockpeople, reports from farmers who already transitioned to alternative systems are that they would 'never go back to crates'. Appropriate, policy initiatives can support the transition amongst those who lack experience, are unwilling to take risks or are under pressure from their peers to 'keep doing the same thing'.

New harmonized baseline legislation, with any compromises inherent in trying to meet all stakeholder' needs, may seemingly make only a relatively small difference to the welfare of an individual sow and litter. However, a large population of animals will experience some enhancement in the quality of their lives. In parallel with legislation, individual labelling or assurance schemes could reward those who choose to go further in adopting full free farrowing and associated welfare aspects as a market-driven activity. Whilst initially only influencing the welfare of a few animals, such labelling schemes will provide a basis of experience for the rest of industry to follow.

Author contributions

EB: Conceptualization, Writing – review & editing, Writing – original draft. VM: Writing – original draft, Conceptualization, Writing – review & editing. LB: Writing – original draft, Conceptualization, Writing – review & editing. SE: Conceptualization, Writing – review & editing, Writing – original draft.

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Conflict of interest

Author VM was employed by company SEGES Innovation P/S.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be constructed as a potential conflict of interest.

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