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for Animal Welfare *Pigs*

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January 2023

This review is a publication of the European Union Reference Centre for Animal Welfare Pigs (EURCAW-Pigs). EURCAW-Pigs was designated by the European Union on 5 March 2018 through Regulation (EU) 2018/329, in accordance with Articles 95 and 96 of Regulation (EU) 2017/625.

Colophon and disclaimer
Access to document at https://doi.org/10.5281/zenodo.7678702. Also to be downloaded at https://edepot.wur.nl/587502

In this EURCAW-Pigs review, the scientific knowledge about sow transport is reviewed against the background of the relevant European legislation, including a discussion of preparation for transport, how sows are picked-up by vehicles and the journey to an abattoir. The final part of this review covers relevant legislation as well as the proposal of potential indicators of sow welfare during transport.

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Co-funded by
the European Union

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1 Executive Summary

Transport is a multifactorial stressor for animals, which may be exacerbated by certain animal characteristics existing before initiation of transport as such. The European regulations (Council Regulation 1/2005 and to a lesser extent 853/2004) lay down rules for the protection of animals during transport including information about fitness for transport. Council Directive 2008/120/EC lays down minimum standards for the protection of sows on-farm, which is also relevant here, as this is where the preparation for transport takes place. Recently, EFSA published an opinion on pig housing (EFSA AHAW Panel, 2022a) and an opinion on pig transport (EFSA AHAW Panel, 2022b). Sows are covered in both of these. In this EURCAW-Pigs review, the scientific knowledge about sow transport is reviewed against the background of the relevant European legislation, including a discussion of preparation for transport, how sows are picked-up by vehicles and the journey to an abattoir. Other aspects of sow transport – that are relevant for animal welfare – have already been covered in other EURCAW-Pigs-reviews (Bracke et al., 2020; Herskin et al. 2021). Sometimes sows – at the end of their productive life – are called 'end-of-carrier'-animals, but in this EURCAW-Pigs review, the less euphemistic term 'cull sow' is used. It is also the most often used term in scientific literature. The final part of this review covers relevant legislation as well as the proposal of potential indicators of sow welfare during transport.

2 Introduction

The main product of the pig industry is meat from finishers, but also sows are slaughtered after their productive lives. A 'cull sow' is a sow for whom herd managers or stockpersons have decided that the productive phase should end. The timing of a decision to cull a sow depends on several factors, and cull sows are, thus, a rather diverse group constituting of sows as young as parity 1 and above parity 10. Among the available studies of cull sows, a median parity of around 5 seems typical, but with a large variation within and between studies (De Jong et al., 2014; Zhao et al., 2015; Fogsgaard et al., 2018).

Some sows die while on farm, and some are killed there, but most cull sows are transported to slaughter, which is the topic of this EURCAW-review. Sows dying on farm or being killed there, are beyond the scope of this review. In Europe, a culling rate of around half of the sows per herd per year is not unusual (Zhao et al., 2015), which means that millions of sows are transported to slaughter each year. They are all transported by road – either within or between MSs, of which some (for example Denmark (Anonymous, 2020) and Germany (Anonymous, 2009)) have national legislation setting 8 hours as the maximum journey duration for this animal category (in Germany only allowed to be transported for more than 8 hours if transported in a Type II vehicle).

Across the different pig categories, transport is a multifactorial stressor (Marchant-Forde and Marchant-Forde, 2009), with effects on all pig types (Rioja-Lang et al., 2019; EFSA, 2022b). Some scientific attention has been directed towards the cull sow category, forming the basis of this EURCAW-review. Among the primary concerns for the welfare of cull sows during transport are (a) fitness for transport (Grandin, 2016); (b) the sensitivity of these animals towards heat stress (Brown-Brandl et al., 2014; Cabezon et al., 2017); and (c) the tendency of sows to fight when mixed with unfamiliar conspecifics (Greenwood et al., 2014). Based on findings such as increased mortality upon arrival at the abattoir compared with finishers (Vecerek et al., 2015;

Peterson et al., 2017), sows are considered more vulnerable towards transport than most other pig categories. Recently, EURCAW-Pigs reviewed fitness for transport in pigs (Herskin et al., 2021). Below, the two other concerns are described further in relation to selected stages of a typical journey to an abattoir.

As mentioned by Herskin et al. (2021), the European pig production has, during recent decades, undergone structural changes. These include increasing herd sizes and changes in the slaughter industry towards fewer and larger units, thereby leading to increased transport distances from farms to abattoirs. This has especially been the case for sows, the carcasses of whom are not accepted at all abattoirs slaughtering finishers.

In this review, animal-based indicators known from animal welfare science (e.g., from Welfare Quality®, 2009) and the recent suggestions from EFSA (EFSA AHAW Panel, 2022ab), are discussed and proposed as potential indicators of sow welfare during selected stages of transport. In accordance with the recent EFSA opinion on pig transport (EFSA AHAW Panel, 2022b), this EURCAW-Pigs review focus on the **preparation for transport** (including pick-up and fitness for transport; see section 3.2) and the **journey** or so-called transit stage, where the animals are in the vehicle. The review could also have included loading/unloading from vehicles, but in these matters, EFSA (EFSA AHAW Panel, 2022b) concluded that sows do not differ considerably from other pig categories, and these stages of transport have, therefore, not been prioritized. Even though sow welfare may be challenged in the days before being picked-up for transport, as well as in lairage at the abattoir, it is beyond the scope of this review to include these stages of a sow's life. In the final section, relevant parts of the European Regulation laying down rules for the protection of animals during transport (Council Regulation 1/2005), for the hygiene of food stuffs (Council Regulation 853/2004) as well as for control posts and route plans (Council Regulation 1255/97) are introduced.

3 Scientific knowledge on sow transport and how this practice links to animal welfare

3.1 Focus areas for sow welfare during transport

There are three focus areas for sow welfare during transport: fitness for transport, susceptibility to heat stress and inter-sow aggression induced by the mixing of sows.

Fitness for transport

Recently, EFSA (EFSA AHAW Panel, 2022b) concluded that questions about fitness for transport are among the major concerns for sow welfare during transport. Due to the general health impairment of a large proportion of cull sows (e.g., Fogsgaard et al., 2018), compared to average finishers, sows may experience a higher risk of worsening of pre-existing health conditions (e.g., lameness), as well as a higher risk of new health conditions (e.g., lesions from fighting) occurring during transport. Therefore, fitness for transport is concerned one of the three 'focus areas' discussed in Section 4, which are relevant for animal welfare inspections, but as mentioned above, EURCAW-Pigs have already reviewed the fitness for transport of pigs, and readers are referred to this material for further information (Herskin et al., 2021).

Susceptibility to heat stress

The term heat stress can cover different definitions. According to the definition recently published by EFSA AHAW Panel, (2022c), the term 'heat stress' is defined as: 'A situation, where an animal experiences stress and/or negative affective state(s) such as discomfort and/or distress when exposed to a high effective temperature'. This definition differs to some extent from other proposed definitions of heat stress, focusing on lack of ability to cope or on performance loss (e.g., Gourdine et al., 2021). In this review, the definition proposed by EFSA is used.

Pigs are special among mammals when it comes to their susceptibility to heat stress (see recent review by Gómez-Prado et al., 2022). The reasons for this are in particular that most of their sweat glands are non-functional, their lungs are relatively small, leading to a reduced ability to dissipate heat by panting, and they carry a thick subcutaneous adipose tissue layer, impeding radiant heat loss. Thus, pigs have difficulty dissipating heat and may experience heat stress, especially when high ambient temperature and high humidity are combined (Ross et al., 2015). Conditions that are also relevant during transport.

EURCAW-Pigs has already reviewed climate control during transport of pigs (Bracke et al., 2020). Readers are referred to this text for basic knowledge about pigs and heat stress. Specific aspects that are relevant for sows during transport are reviewed below.

The recent EFSA opinion on transport of pigs (EFSA AHAW Panel, 2022b) considers that sows are more vulnerable to heat stress than pigs of lower body size. Among reasons given for this difference are their large body size and relative low surface area: body weight ratio, higher energy intake relative to maintenance requirement (in lactating sows), and higher subcutaneous fat tissues (Renaudeau et al., 2012; Gourdine et al., 2021).

This means that the reproductive status of sows affects their susceptibility to heat stress, and that ongoing milk production probably is a risk factor compared to dry animals. Sows can be sent to slaughter at all stages of the reproductive cycle (except for the last 10% of pregnancy (according to Council Regulation 1/2005), and in some MSs, sending sows to slaughter in the last 30% of pregnancy is prohibited by national legislation (Anonymous, 2008). Considerable numbers have, though, been reported to be slaughtered early post-weaning (when milk is still produced) (Fogsgaard et al., 2018). In the days just before and after weaning of the piglets, lactating sows are especially sensitive to heat stress, as their milk production is very high at this stage (Williams et al., 2013). Another parameter with relevance to heat stress is the heat production from the animals. For sows heat production has been shown to increase steadily from farrowing to weaning (Brown-Brandl et al., 2014).

Heat stress in sows has received scientific attention in the last years, but almost only in relation to on-farm productivity and welfare (e.g., Bjerg et al., 2020; Gómez-Prado et al., 2022), whereas only a few studies have focused on heat stress during transport of sows (e.g., Thodberg et al., 2019, 2022).

Based on a review of the available scientific literature, and especially the knowledge presented in two recent reviews focusing on heat stress in pigs (Bjerg et al., 2020; de Castro Junior and Silva, 2021), EFSA (EFSA AHAW Panel, 2022b) concluded that if negative impact from heat stress during journeys should be fully prevented, sows should be transported in their thermal comfort zone (see Bracke et al. (2020) for a discussion of this concept). EFSA also suggested that the risk and severity of heat stress is likely high when the thermal

conditions reach the upper critical temperature (see EFSA (2022b) and Bracke et al. (2020) for a discussion of this concept).

In addition, EFSA (2022b) estimated the upper thresholds of the thermal comfort zone and the upper critical temperature for sows to 20°C and 22°C, respectively. Based on studies of behavioural preferences, Robbins et al. (2021) suggested that thermal preferences of sows depend on the reproductive stage, and that late-gestation sows preferred cooler temperatures than mid-gestation and nonpregnant sows. Overall, the sows preferred to stay at temperatures around 14-15°C. Importantly, for variations of temperature and relative humidity, the higher the levels of relative humidity, the lower the upper thresholds of the thermal comfort zone and the upper critical temperature, when measured as temperature only. Based on the current knowledge, however, it is not possible to give estimates of the effective temperature in trucks transporting sows, expressed as this relation.

Fighting between sows induced by the mixing of unfamiliar individuals

Under natural conditions, sows live in groups of related individuals. Within a group, a hierarchy preventing overt fighting between group members exist (Greenwood et al., 2014). Under production conditions, sows are frequently mixed with non-penmates, a management practice that has received considerable scientific attention. See Schubbert et al. (2020) for a review of this practice. It is, thus, well-documented that sows – when mixed with unfamiliar individuals – will fight to re-establish a hierarchy, and that the fighting can be severe and of considerable duration. Consequently, the mixing of unfamiliar sows has long been recognised as a welfare problem, mainly due to inter-sow aggression. Therefore, fighting among sows is considered a "focus area" for inspection. Chapter 4 informs about indicators that can be used to detect fighting between sows even if the fighting itself cannot be observed.

During transport of sows, mixing of unfamiliar animals is almost unavoidable (Herskin et al., 2020a; Thodberg et al., 2020), and can have consequences for the animal welfare. Even though documentation as such is currently missing, it is highly likely that sows will fight during transport, when mixed with unfamiliar individuals. This behaviour can challenge the continuous fitness for transport, increase the risk of heat stress, and thus challenge the overall welfare of the sows. In a yet unpublished study in Denmark, Kobek-Kjeldager et al. (in prep.) found that almost 80% of the sows initiated aggressive interactions during the journey (max journey duration 8 hours, space allowance of at least 0.8 m^2/250 kg sow, and data from 28 journeys) and only a few never received aggression when they were transported to slaughter, under commercial conditions with 12 sows per truck compartment.

The inter-sow aggression may, however, not be limited to the journey stage. Herskin et al. (2020b) studied behaviour of sows in on-farm pick-up pens (temporarily holding the sows before being picked-up from a farm, see Section 3.2.1). The cull sows were housed in these pens during 24 hours after on-farm mixing as part of the preparation for transport. Herskin et al. (2020b) found that the clinical condition of the sows showed signs of deterioration while they waited 24 hours to be picked-up, as judged by an increased number of superficial skin lesions and increased gait score. The median occurrence of aggressive interactions per pen holding 3-4 sows during the initial 6 hours post-mixing was 33, ranging from 11–55 aggressive interactions.

Scientific evidence on reducing the level of aggression in pick-up facilities or pick-up vehicles is not available. However, from studies of other pig categories, or sows that continue in the production, it has been suggested that the consequences of mixing in terms of aggression and injury can be mitigated to some extent by reducing group size (Rabaste et al., 2007) and by ensuring enough space for subordinate individuals to move away from aggressive ones. This may be further improved, if the place where the pigs are kept, is provided with hiding places, such as half walls. In addition, it is likely that provision of ample resources, such as rooting materials and water, as well as by keeping the thermal conditions within the thermal comfort zone of the animals, can reduce the level of aggression (as reviewed by Schubbert et al. (2020)). In the Scientific Opinion concerning the welfare of pigs on farm, EFSA (EFSA AHAW Panel, 2022a), has introduced a pen concept including such mitigating measures – called a mixing pen (Figure 3.1.1). Further studies involving cull sows are needed to verify whether initiatives like that can limit the occurrence of fighting – during the preparation phase and later in the journey when sows are transported to slaughter.

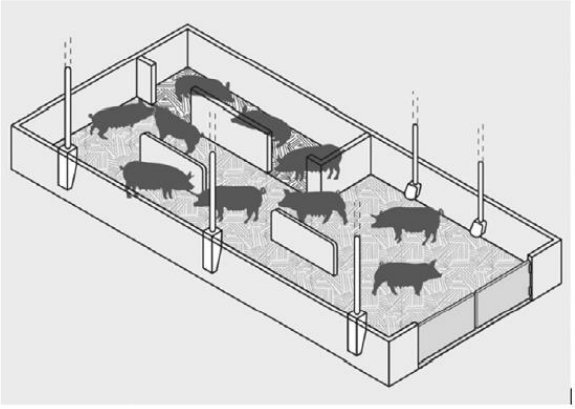

Figure 3.1.1: Example of a mixing pen, where pigs are offered resources aimed to reduce the consequences of post-mixing fighting. Drawing printed from EFSA (EFSA AHAW Panel 2022a) with permission.

3.2 Knowledge about sow welfare during relevant stages of transport

Preparation for transport

Across production systems and MSs, the preparation of sows for transport may differ substantially, but very limited scientific knowledge exists on the different links in the pre-slaughter logistic chain of sows (Miranda-De La Lama et al., 2014). The place of departure is typically the farm of origin, but it is also possible that sows depart from assembly centres, markets or auctions. Regardless of this variability, preparation is an important phase in terms of sow welfare, as careful preparation may lower the welfare impact of transport. Preparation for transport holds no formal scientific definition, but in this EURCAW-Pigs review this stage of transport of sows includes the picking-up of sows on-farm, as well as the assessment of fitness for transport. In addition, a short section on pre-transport fasting and pre-transport access to water is included.

Normally, a relatively low proportion of the sow population from a specific farm is sent to slaughter at the same time, which means that vehicles must visit several farms to make a full load on their way to an abattoir (Thodberg et al., 2022), or must collect animals from an assembly centre. In addition, in several MSs, not all abattoirs can handle sow carcasses. This means that sows often will be transported either quite far, or for quite some time, to reach the destination. Having multiple stops on the way to an abattoir, to load sows from other farms, is also a challenge for the biosecurity. One way to reduce risk of spread of diseases from this practice, is the use of so called 'pick-up vehicles' or 'transfer vehicles' (Figure 3.2.1) (Herskin et al., 2017). To prevent vehicles already holding sows on board from driving close to buildings holding pigs, the sows to be transported to slaughter on a particular day may be loaded into some vehicle and driven to the nearest public road. Then, the sows can be transferred from the 'pick-up-vehicle' to the truck when it arrives. Depending on the duration of such a stay in a 'pick-up vehicle', the interval from leaving the home pen to arrival at the abattoir can be longer than the journey as such, and these vehicles may thus constitute an extra link in the pre-slaughter logistic chain of the sows, by prolonging the total journey time but also by adding a stay in yet another environment (Miranda-De La Lama et al., 2014).

Figure 3.2.1: Sows kept in a 'pick-up vehicle' outside farm buildings, near a public road, awaiting the pick-up by the truck taking them to the abattoir. Figure printed from EFSA (EFSA AHAW Panel 2022b) with permission.

If sows are not brought to a public road and loaded from a 'pick-up vehicle' they may also be sorted and prepared on-farm, e.g., by use of so-called shipping pens (Goumon and Faucitano, 2017) or pick-up pens as mentioned above (Herskin et al., 2020b). It is, therefore, almost a given that sows will be mixed with unfamiliar sows in some kind of pick-up facility, which will lead to aggression and consequently to skin lesions or other injuries (as reviewed by Brandt and Aaslyng, 2015). Whether the use of pick-up pens changes the total level of post-mixing aggression during the wait before loading and during the journey as such, is not known.

Before being sent to slaughter, pigs are normally fasted for hours while still on-farm. In 2020, EFSA AHAW Panel described how fasting of animals destined for slaughter is done to reduce gut content and prevent release and spread of bacterial contamination through faeces during transport and lairage, as well as through the spillage of gut contents during carcass evisceration. Within reasonable limits, fasting before slaughter may also be beneficial for animal welfare, as vomiting during journeys (due to motion sickness) may be

prevented, and the risk of hyperthermia may be reduced (Averos et al., 2008). Survey studies focusing on finishers have also found increased risk of mortality during journeys in pigs that were not fasted before transport (Averos et al., 2008). However, as reviewed by Zurbrigg et al. (2017), since these data come from surveys, fasting *per se* may not be a causal factor of the mortality as the practice of pre-transport fasting is probably confounded by other pre-slaughter management, such as pig sorting method.

Nevertheless, the number of studies of pre-transport fasting involving sows is very limited. Based on the available evidence coming almost exclusively from finishers, EFSA recently concluded that pre-transport fasting duration should not be too long and should be appropriate for the planned journey duration, the pig category, as well as take into consideration whether pigs are transported for slaughter or for further fattening/production (EFSA AHAW Panel, 2022b). EFSA (EFSA AHAW Panel, 2022b) justified this conclusion by stating that fasting is often not done for the sake of animal welfare but for reasons of food safety and hygiene. From an animal welfare point of view there is a risk that pre-transport fasting leads to welfare consequences such as hunger, and indirectly to increased aggression (as reviewed by Faucitano, 2018), injuries and handling stress, as fasted pigs may be more difficult to handle (Dalla Costa et al., 2016; Acevedo-Giraldo et al., 2020). Finally, no or too short period of fasting before transport may also have welfare consequences for the animals in terms of increased risk of motion sickness and hyperthermia. Importantly, however, all available studies of pre-transport fasting have involved finishers, and whether there are effects of fasting on, e.g., aggression in cull sows – where a significant proportion is lactating and used to a high feeding level (Thodberg et al., 2019) - is not known.

Based on reasoning as outlined above, EFSA (EFSA AHAW Panel, 2022b) recommended that until evidence-based thresholds are established, finishers should be fasted less than 10 hours, and that for other pig categories, the pre-transport fasting should likely be shorter.

In terms of animal welfare, the preparation of animals for transport should also involve attention to water balance. As discussed later in this section ("Thirst"), the evidence for the welfare benefits of providing sows with water during journeys is lacking. To make sure that sows are well hydrated before transport, they therefore should be allowed free access to water during the preparation phase. In a questionnaire sent to Danish sow farmers supplying one large abattoir, asking about their management of cull sows, Herskin et al. (2020a) reported that of the around 80% of the respondents using pick-up vehicles for the preparation of the sows, only 4% reported to provide water to the animals. Among the 17% of respondents using pick-up pens for their sows, 48% reported to give the animals access to water while they were there.

The journey

When sows are in the vehicle transporting them to slaughter, their level of animal welfare depends on several factors such as journey duration, space allowance, ambient conditions (temperature, humidity, vibrations, and noise) vehicle design and driving conditions (as reviewed for pig transport in general by Schwartzkopf-Genswein et al. (2012) and Faucitano and Raj (2022)). The multifactorial nature of animal welfare during journeys is also recognized in the recent EFSA opinion, where several welfare consequences were selected as highly relevant during this stage, such as stress from mixing, heat stress, injuries, motion stress (due to the moving vehicle) hunger, thirst, resting problems and restriction of movement (EFSA AHAW Panel, 2022b). Below, major welfare consequences that are relevant while the sows are in the vehicle transporting them to slaughter, are discussed in terms of animal welfare.

Heat stress

For journeys as well as loading/unloading, the risk of heat stress is increased if temperatures are high (especially when combined with high humidity as explained above), when the vehicle or the animals are exposed to solar radiation, when ventilation rate inside the vehicle is insufficient, when sows exert physical effort, are exposed to high stocking density and/or time off water.

Irrespective of whether vehicles are naturally and/or mechanically ventilated, the major determinant of the environmental conditions inside the vehicle, is the outdoor weather conditions. In all vehicles without temperature control (the vast majority of trucks transporting sows), the effective temperature in the vehicle is expected to be higher than the outside. Heat production of the animals inside the truck will, depended on ventilation rate, increase the inside temperature (Pasquale, 2022). Furthermore, solar radiation can also play a significant role by heating the vehicle as compared to the outside temperature.

Transport of sows will often include stationary periods, e.g., when sows are collected from multiple farms, during driver breaks or while waiting to be unloaded at the abattoir. According to Thodberg et al. (2022), temperatures rise quickly during stationary periods, to levels where sows would experience heat stress, with the internal temperature increasing by 7°C during a 10 min stationary period under varying ambient conditions.

To prevent heat stress while sows are in the vehicles transporting them to slaughter, sows should be transported in their thermal comfort zone, for which one estimate of the upper boundary is 20°C as explained above. If outside temperatures are higher than the thermal comfort zone, the risk of heat stress can be lowered by avoiding transport during the hottest hours of the day. Appropriate ventilation should always be ensured, as this will remove metabolic heat from the animals. In naturally ventilated trucks, slow driving speed or stops will decrease ventilation rate and therefore requires special attention during warm weather conditions. Transport vehicles should park in the shade during stops and when waiting at places of arrival especially when unloading is delayed.

However, very few studies focusing on heat stress in sows during journeys exist. Thodberg et al. (2022) collected temperature data from 39 loads of cull sows sent to slaughter in Denmark during all seasons involving journeys up to 8 hours. The authors found that when sows were kept at the recommended Danish stocking density of 0.80 m^2/250 kg sow and with passive ventilation (with the possibility for the driver to activate mechanical ventilation), the temperatures measured by sensors placed near the ceiling of the rear compartment on the lower deck did not stay within the thermal comfort zone of sows. The temperatures even rose above the upper critical temperature in summer when the vehicle was moving, and in summer and autumn during waiting upon arrival. Importantly, during the journeys, drivers were not informed about these data, and thus may not have adjusted the use of mechanical ventilation accordingly.

The temperature inside a vehicle transporting sows also depends on the stocking density of the animals. Space allowance during transport of pigs has already been reviewed by EURCAW-Pigs (Bracke et al., 2020), and readers are referred to this text. Lowering space allowance increases the number of sows that are loaded onto a vehicle and lead to increased production of metabolic heat and moisture from the animals (EFSA AHAW Panel, 2022b). Thus, increasing space allowance can help to reduce the risk of heat stress, by allowing the sows enough space to lie on their side without touching each other (as discussed by Bracke et al. (2020)

for pigs in general). However, whether increased space allowance can contribute enough to the thermal conditions inside the vehicle is uncertain. Therefore, it is probably a welfare benefit to increase the space allowance for sows during transport on hot days to allow lateral lying, but how much the inside temperature in the vehicle will be reduced is not known. Preventing heat stress during all stages of transport is identified as a "focus area", for which indicators are proposed in Section 4.

Truck movement and motion stress

As reviewed by Valadez Noriega and Miranda de la Lama (2020), animals are exposed to vertical, lateral and horizontal movements of the truck during transport. This means that they may experience stress and/or fatigue due to the forces exerted as a result of acceleration, braking, stopping, cornering, gear changing, vibrations and uneven road surface (as reviewed by EFSA, 2022b).

The term vibration describes movement of a body to the reference position, and occurs in principle because of an excitation force that causes motion. Across animal groups, vibration has been shown to affect animal behaviour and induce physiological changes as well as to cause effects at the cellular and molecular levels (Reynolds et al., 2019). Therefore, vibrations have a considerable potential to affect animal welfare status. Recently, Morris et al. (2021) showed that, in North American trucks transporting finishers, vibration rate varied according to the location of the pigs inside the vehicle. However, so far no studies of vibrations in trucks transporting sows, or focusing on the response of sows to truck motion, exist. In a yet unpublished study, Kobek-Kjeldager et al. (in prep.) observed the behaviour of sows during transport to slaughter under commercial Danish conditions, and found that the number of sows lying down during journeys (lasting up to 8 hours) was low (a median of 4.5% of the sows was observed lying per journey) and very variable (the average proportion of sows lying during scan observations ranged from 0 to almost 30%). Thus, sows seem to mainly be standing during transport, a finding that may influence how they respond to truck movement as compared to other pig categories (e.g., weaners), where lying is more common.

However, from other pig categories it is known that motion stress may lead to motion sickness, and that motion stress is increased during driving events, such as acceleration, braking and turns. One way to limit the stress from the moving vehicle is by careful driving. Rough driving including high acceleration and forceful braking, may cause postural instability, leading to toppling, sliding and excessive corrective muscular action. This results in bruisings, muscular fatigue, fear and general injuries to animals during transport (Driessen et al., 2020a,b).

Thirst

According to current EU Regulation (Council Regulation 1/2005) vehicles transporting pigs on journeys exceeding a duration of 8 hours, must be provided with water. According to EFSA (EFSA, 2022b), pigs may not be thirsty during the initial phase of the journey (if they have been offered water during preparation for transport), but thirst will develop over time if water is not freely accessible. EFSA (EFSA AHAW Panel 2022b) concluded that for an average pig (a finisher) it is likely that pigs are thirsty within 8 hours without access to water, whereas for example lactating sows most probably are thirsty after a shorter interval.

Currently no information exists on how soon after initiation of driving sows start to drink water, or how much water sows drink during transport, if it is offered to them. If sows for some reason are not drinking during a journey, they might develop thirst even though drinkers have been in place. It is not known how drinkers should be designed and positioned to accommodate the need for water of sows. In addition, the intake of water might be – but is not known to be – influenced by lack of familiarity with the type of drinkers, lack of space to move around inside a vehicle, as well as potential effects of the behaviour of the other sows in a vehicle compartment.

Recently, EFSA (2022b) reviewed potential animal-based indicators of thirst in pigs. Among the suggested candidates were physiological measures such as plasma osmolality (Clemens et al., 1986) or packed cell volume (Turner and Hodgetts, 1959). In addition, intake of water after unloading or when allowed to drink from a bucket was also suggested. It is stated, though, that none of these potential indicators have been validated in terms of transport and that science-based cut-offs in journey time have not been established either. There are, however, studies in finishers showing relationships between journey duration and drinking behaviour of the pigs upon arrival in lairage (Brown et al., 1999; Goumon et al., 2013). In a not yet published study, Jensen et al. (in prep.) observed the drinking behaviour of sows during the first hour in lairage as a potential indicator of drinking motivation after transport to slaughter in vehicles without access to water. The results showed that not all sows drank within the first hour upon arrival at the abattoir. Within the studied journey durations (1-8 hours), sows approached the drinkers more after longer journeys, potentially confirming the use of this behaviour as an indicator of thirst. However, when outside temperatures were high, sows seemed to experience a motivational conflict between the seeking of drinkers and motivation to be lying laterally, as these behaviours were decreased and increased, respectively, when temperatures were high, compared to days of lower temperature.

Resting problems and horizontal space

As reviewed recently by EFSA (2022b), the horizontal space taken up by animals in different postures can be estimated by allometric equations, such as [$A = kW^{2/3}$], where k is a constant and W represents live weight in kilograms. According to Petherick and Phillips (2009), the k-value needed for pigs in a group to lie down sternally is 0.019, corresponding to a space allowance of 0.75 m^2 for a 240 kg sow. However, this suggestion has not been validated during transport, and as mentioned above, the only data available suggest that sows most often will not lie down during transport (Kobek-Kjeldager et al., in prep.). This means that even though the stocking density of vehicles transporting sows are compliant with current EU Regulation (1/2005) sows may not rest during transport (studied for journeys up to 8 hours), and may therefore develop resting problems, potentially developing into fatigue over time, during transport. In a study by Gerritzen et al. (2013) into the effect of space allowance during transport of finishers, it appeared that at a lower stocking density (180 kg/m^2) pigs were lying down during driving more frequently than pigs transported at a normal commercial stocking density of 235 kg/m^2. This finding indicates that finishers show resting behaviour when space is available. Whether this is the case for sows, too, is not known, but is considered likely. As suggested by EFSA (2022b), the duration of the resting problems will depend on the duration of a given journey, and severity is expected to increase with increasing duration.

As already addressed, vehicle movement is a stressor in itself, but also can be considered as a risk factor for the development of resting problems, especially when driving is not done in a calm and focused way, and/or when road conditions are of lower quality. Under such conditions, sows will need to adjust posturally to acceleration changes, to maintain their balance.

No studies involving comparison of different stocking densities are available for sows during transport. Based on estimates of the space required to lie down in a semi-recumbent posture, EFSA (2022b) recommended that sows should be allowed a horizontal space corresponding to a k-value of 0.027, which is equal to 1.04 m^2 for a 240 kg sow. Whether this space allows sows to maintain balance or to access drinkers is not known. In addition, this space recommendation has not been validated during transport.

Vertical space

Not only the horizontal space, but also the vertical space in a vehicle transporting sows is important for their animal welfare. When pigs are transported, a deck height forcing them to adopt abnormal postures is problematic. In addition, low deck height can be associated with reduced ventilation, lack of ability to move around, and lack of space for natural movements, for example when urinating. Currently no studies in sows are available documenting to what extent different deck heights live up to these requirements. However, there are estimates of how tall sows are at the highest point when standing. Petherick (1983ab) proposed that pig height can be expressed by [height (m) = $0.156W^{0.33}$], where W is the weight of the pigs (in kg). When this formula is used, a sow of 240 kg is 0.95 m tall.

Currently, there are no legal requirements for the minimum vertical space allowance provided to sows during transport. Some years ago, SCAHAW (2002) recommended that pigs are provided with 30 cm free space above the tallest point (often the back near the hips) when transported in vehicles that are naturally ventilated, and 15 cm free space when transported in vehicles that are mechanically ventilated. However, these recommendations were not based on scientific evidence as such. In the current EU Regulation (1/2005) it is stated that animals should be allowed a deck height providing adequate ventilation above their bodies in a natural standing position, and without hindering their natural movement. However, it is not specified what deck height is sufficient for this.

4 Key areas to focus on in the different stages of transport

4.1 Fitness for transport

EURCAW-Pigs has already reviewed the fitness for transport of pigs, and readers are referred to this material for further information (Herskin et al., 2021).

4.2 Heat stress

Typical responses measured as indicators of heat stress in pigs under experimental conditions are **respiration rate (RR),** gastrointestinal tract temperature (GIT) and rectal temperature (RT) (as reviewed by Mayorga et al., 2019), and some focus has been given to indicators of performance, such as voluntary feed intake or average daily gain (Huynh et al., 2005). More recently, behavioural indicators have been included as well.

Examples of these are thermal preference studies (Robbins et al., 2021). In a study involving gilts exposed to temperatures of 15–30°C while kept in individual crates, Canaday et al. (2013) observed increased occurrence of postural changes, increased lying, and increased lateral lying at the highest temperatures.

An early response of pigs to increasing thermal load is to increase the RR, and thus the respiratory evaporative heat loss. As described by Renaudeau et al. (2012), initially rapid shallow breathing (thermal polypnea) leads to increased air passage through the upper respiratory tract. When temperature rises further, the breathing shifts to a slower, deeper, **panting** phase (thermal hyperpnea) characterized by increased alveolar ventilation rate. As defined by Collier and Gebremedhin (2015), panting can be considered an increase in respiratory frequency combined with decreased tidal volume, thereby increasing upper respiratory tract ventilation while preserving alveolar ventilation. The former leads to increased evaporative loss of heat. Operationally, panting can be identified by open mouth breathing (Bracke et al., 2020), and has been reported in pigs before, during and after transport.

Other signs of heat stress in pigs are skin discoloration (patches of reddish/bluish skin) and increased sitting in dog-style position (Ritter et al. (2008), even though this behaviour is most likely not specific for heat stress, but an expression of general physical discomfort). Findings by Haley et al. (2008) and Peterson et al. (2017) showing that more animals are found dead on arrival (DOA) in abattoirs during hot weather in summer compared to other seasons, may suggest this as another, however 'end-point' and unspecific indicator of heat stress. Similarly, the finding of non-ambulatory pigs in vehicle compartments or lairage pens, may also be an unspecific indicator of heat stress (Correa et al., 2013).

4.3 Fighting among sows

As reviewed above, aggressive interactions between sows, probably induced by pre-transport mixing of unfamiliar animals, are a challenge to the welfare of sows during transport. In line with this, EFSA (2022b) recommended that sows are not mixed at any stage of transport. So far, no studies have linked the occurrence of aggressive interactions to clinical indicators of fighting in sows, such as scratches and wounds, but Thodberg et al. (2019) found increased occurrence of superficial skin lesions in sows after arrival to the abattoir and suggested that these were the outcome of fighting.

Importantly, however, inter-sow aggression may not be limited to the journey stage. Herskin et al. (2020b) studied behaviour of cull sows in pick-up pens during 24 hours after on-farm mixing, as part of the preparation for transport, and found that the clinical condition of the sows showed signs of deterioration while they waited 24 hours to be picked-up, as judged by an increased number of superficial skin lesions and increased gait score. The median occurrence of aggressive interactions per pen holding 3-4 sows during the initial 6 hours post-mixing was 33, ranging from 11−55. Thus, unless the duration of different stages of transport is taken into consideration, skin lesions observed upon arrival at the abattoir need not have been inflicted during the journey as such.

However, currently, no validated protocol for the assessment of sow welfare before, during and after transport has been described, and therefore benchmark values documenting good animal welfare do not exist for any of the animal-based indicators suggested in this EURCAW-Pigs review.

5 Minimising welfare problems: obtaining valid animal-based data

In this last section of the review, attention is drawn to one important element in the work to align and improve the assessment welfare of sows during transport.

The assessment of sow welfare during transport is challenged by the lack of visibility of the animals – at least during the journey stage – and often also during preparation, as farmers only send sows every week or every other week (Herskin et al., 2020a), and inspectors therefore cannot expect to see cull sows during a standard farm inspection.

Even when sows are visible and accessible by the inspector, some of the animal-based indicators have low feasibility for recording during routine transport inspection. So far, no studies have evaluated different animal-based indicators of sow welfare during transport in terms of feasibility. A similar lack of knowledge exists with reference to sensitivity and specificity of animal-based indicators in the context of sow transport.

The problem of visibility and accessibility can be handled by use of sensors, such as cameras or devices recording the thermal conditions inside vehicles. Currently, such technological tools are only applicable in transport practice to a certain degree, and studies of validity and reliability of these indicators (as discussed by Knierim and Winckler (2009) for welfare of cattle) are required. A recent example of the influence of e.g., sensor placement when thermal conditions are assessed during animal transport, is the work by Herskin et al. (2022), quantifying temperature in trucks transporting weaner pigs over long distances. Here, the built-in sensors of the truck, collecting data on a daily basis as part of the compliance with European Regulation (1/2005) were situated in the outer wall of the trucks, to allow the hydraulic movement of decks and the washing/cleaning af trucks between loads. For the experimental study, purpose-made sensors were placed much closer to the pigs in each compartment – in the center of the horizontal axis of the truck, and at pig height. Analysis of the temperatures obtained with the two differently placed types of sensors showed that the built-in sensors to a high extent reflected the outdoor temperature, and that relatively large differences between the sensors placed in the wall and sensors placed near the pigs, were obtained. Thus, before data from sensors are used to interpret sow welfare during transport, the chosen placement of them as well as other methodological aspects, need to be examined.

During preparation, loading and unloading, sows must be properly inspected, and animal-based indicators in principle utilised. In the future, the suggested visually recognisable indicators may be supplemented by auditory indicators.

6 Legal requirements

The legal requirements regarding transport of sows are stated in the Council Regulations (EC) No 1/2005 and 1255/97 and additional text can be found in 853/2004 as well. The sections of the legislation relevant for pigs are presented below:

6.1 Council Regulation (EC) No 1/2005 on the protection of animals during transport and related operation

Council Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC, Council Regulation (EC) 1099/2009 and Regulation (EC) No 1255/97 determines welfare conditions during transportation of animals:

Article 15: Checks to be carried out by the competent authority at any stage of long journeys
By December 14, 2022. This article was removed, and is now replaced by Article 21 in Council Regulation 2017/625 on official controls. See below.

Annex 1, Chapter 1: Fitness for transport
1. No animal shall be transported unless it is fit for the intended journey, and all animals shall be transported in conditions guaranteed not to cause them injury or unnecessary suffering.

2. Animals that are injured or that present physiological weaknesses or pathological processes shall not be considered fit for transport and in particular if:

(a) they are unable to move independently without pain or to walk unassisted;

(b) they present a severe open wound, or prolapse;

(c) they are pregnant females for whom 90 % or more of the expected gestation period has already passed, or females who have given birth in the previous week;

(d) they are new-born mammals in which the navel has not completely healed;

(e) they are pigs of less than three weeks, unless they are transported less than 100 km;

3. However, sick or injured animals may be considered fit for transport if they are:

(a) slightly injured or ill and transport would not cause additional suffering; in cases of doubt, veterinary advice shall be sought;

(b) transported for the purposes of Council Directive 86/609/EEC (1) if the illness or injury is part of a research programme;

(c) transported under veterinary supervision for or following veterinary treatment or diagnosis. However, such transport shall be permitted only where no unnecessary suffering or ill treatment is caused to the animals concerned;

(d) animals that have been submitted to veterinary procedures in relation to farming practices such as castration, provided that wounds have completely healed.

4. When animals fall ill or are injured during transport, they shall be separated from the others and receive first-aid treatment as soon as possible. They shall be given appropriate veterinary treatment and if necessary undergo emergency slaughter or killing in a way which does not cause them any unnecessary suffering.

5. Sedatives shall not be used on animals to be transported unless strictly necessary to ensure the welfare of the animals and shall only be used under veterinary supervision.

6.2 Regulation (EC) No 853/2004 laying down specific hygiene rules for on the hygiene of foodstuffs

Regulation (EC) No 853/2004 of the European Parliament and of the council of 29 April 2004 laying down specific hygiene rules for on the hygiene of foodstuffs:

[*The term 'fitness' cannot be found in this regulation, the content of which, however, mentions animal welfare at the time of arrival to slaughterhouses.*]

Annex II, Section II, 2.f
Food business operators operating slaughterhouses must ensure procedures to guarantee that the condition of each animal is in a satisfactory state as regards welfare on arrival at the slaughterhouse.

6.3 Council Regulation (EC) No 1255/97 concerning Community criteria for control posts

Council Regulation (EC) No 1255/97 of 25 June 1997 concerning Community criteria for control posts and amending the route plan referred to in the Annex to Directive 91/628/EEC:

6.3.1 Article 6
Before the animals leave the control post, the official veterinarian or any veterinarian designated for this purpose by the competent authority shall confirm on the journey log as referred to in Annex II of Regulation (EC) No 1/2005 that the animals are fit to continue their journey.

6.4 Council Regulation (EC) 1099/2009 on the protection of animals at the time of killing

Council Regulation (EC) 1099/2009 of 24 September 2009 on the protection of animals at the time of killing:

ANNEX III Operational rules for slaughterhouses
1. The arrival, moving and handling of animals

1.1. The welfare conditions of each consignment of animals shall be systematically assessed by the animal welfare officer or a person reporting directly to the animal welfare officer upon arrival in order to identify the priorities, in particular by determining which animals have specific welfare needs and the corresponding measures to be taken.

6.5 Council Regulation (EC) 2017/625 on official controls and other official activities

Council Regulation (EC) 2017/625 of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products:

Article 21: Specific rules on official controls and for action to be taken by the competent authorities in relation to the welfare requirements for animals.

1. Official control to verify compliance with the rules referred to in point (f) of Article 1(2) shall be performed at all relevant stages of production, processing and distribution along the agri-food chain.

2. Official controls to verify compliance with the rules laying down welfare requirements for animals in the event of their transport, in particular with Regulation (EC) No 1/2005, shall include:

a. in the case of long journeys between MSs and with 3rd countries, official controls performed prior to the loading to check the fitness of the animals for transport;

b. in the case of long journeys between MSs and with 3rd countries, of domestic equidae other than registered Equidae and domestic animals of the bovine, ovine caprine and porcine species, and prior to those journeys:

i. official controls on journey logs to verify that the journey log is realistic and indicates compliance with Regulation (EC) No 1/2005; and

ii. official controls to verify that transporters comply with applicable international agreements and have valid transporter authorisations and certificates of competence for drivers and attendants; and

iii. official controls to verify whether domestic Equidae and domestic animals of bovine, ovine, caprine and porcine species have been or are to be transported over long journeys.

3. During the performance of official controls and other official activities, the competent authorities shall take the necessary measures to prevent or reduce to a minimum any delay between the loading of the animals and their departure, or during the transport.

The competent authorities shall not detain animals during the transport unless it is strictly necessary for animal welfare or animal or human health reasons. If animals have to be detained during transport for more than 2 hours, the competent authorities shall ensure that appropriate arrangements are taken for their care and, where necessary, their feeding, watering, unloading and accommodation.

4. Where a non-compliance is established following the official controls referred to in point (b) of paragraph 2 and is not corrected by the organiser prior to the long journey, by making appropriate changes to the transport arrangements, the competent authorities shall prohibit that long journey.

5. Where, following the official controls referred to in point (c) of paragraph 2, the competent authorities establish that animals are not fit to complete the journey, they shall give the order that animals be unloaded, watered, fed and rested until fit to continue their journey

Acknowledgements

We thank the other members of the EURCAW-Pigs team, as well as the two external reviewers, Heidi Arndt and Luigi Faucitano, for contributions to this work.

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EU Reference Centre for Animal Welfare *Pigs*

About EURCAW-Pigs

EURCAW-Pigs is the first European Union Reference Centre for Animal Welfare. It focuses on pig welfare and legislation, and covers the entire life cycle of pigs from birth to the end of life. EURCAW-Pigs' main objective is a harmonised compliance with EU legislation regarding welfare in EU Member States. This includes:

- for pig husbandry: Directives 98/58/EC and 2008/120/EC;
- for pig transport: Regulation (EC) No 1/2005;
- for slaughter and killing of pigs: Regulation (EC) No 1099/2009.

EURCAW-Pigs supports:

- inspectors of Competent Authorities (CA's);
- pig welfare policy workers;
- bodies supporting CA's with science, training, and communication.

Website and contact

EURCAW-Pigs' website www.eurcaw-pigs.eu offers relevant and actual information to support enforcement of pig welfare legislation.
Are you an inspector or pig welfare policy worker, or otherwise dealing with advice or support for official controls of pig welfare? Your question is our challenge! Please, send us an email with your question and details and we'll get you in touch with the right expert.

info.pigs@eurcaw.eu

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Services of EURCAW-Pigs

- **Legal aspects**
  European pig welfare legislation that has to be complied with and enforced by EU Member States;
- **Welfare indicators**
  Animal welfare indicators, including animal based, management based and resource based indicators, that can be used to verify compliance with the EU legislation on pigs;
- **Training**
  Training activities and training materials for inspectors, including bringing forward knowledge about ambivalence in relation to change;
- **Good practices**
  Good and best practice documents visualising the required outcomes of EU legislation;
- **Demonstrators**
  Farms, transport companies and abattoirs demonstrating good practices of implementation of EU legislation.

Partners

EURCAW-Pigs receives its funding from DG SANTE of the European Commission, as well as the national governments of the three partners that form the Centre:

- Wageningen Livestock Research, The Netherlands
- Aarhus University, Denmark
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Co-funded by the European Union