Introduction

Pigs provide the greatest weight of meat produced worldwide for human consumption and are farmed on all continents, with the largest populations found in China, Europe, and North America (FAO, 2020). They may be produced in a variety of different systems, depending on the climatic and socioeconomic circumstances of the region. However, they are increasingly farmed in intensive systems which are relatively similar in basic characteristics in all countries (Cameron, 2000). The evolutionary biology of the pig, as an omnivore ranging across many different habitats, has given it great flexibility and adaptability. However, it has also given it genetically engrained behavioural dispositions relevant to its welfare in farmed conditions (Edwards and Grand, 2021). This chapter will describe the reasons for the development of current pig farming methods, the different welfare challenges which can exist in extensive and intensive systems, and the practical ways in which these are being addressed.

Extensive farming systems

A minor part of the world pig population is still produced in more extensive systems which might be considered close to the evolutionary habitat of the species. In subsistence farming, animals may wander freely as scavengers. In Mediterranean countries, traditional silvopastoral systems with indigenous breeds are used for the production of high-value cured product (García-Gudiño et al., 2020). Even in modern production, the reintroduction of agro-forestry systems is being investigated to give benefits of dual land use for energy biomass and meat production (Jørgensen et al., 2018). Extensive systems are also adopted in organic farming, which represents a small but growing sector (Früh et al., 2014). Organic production standards stipulate that animals must have access to the outdoors, although this may sometimes be a concrete out-run rather than pasture. The keeping of pigs at pasture is also seen in some conventional farms, most commonly for breeding animals but also for rearing animals in some smallholder systems or in specialised label production (Edwards, 2005).

Outdoor living

Whilst such extensive systems offer the pig great behavioural freedom, with the ability to exercise choice amongst diverse locations and exhibit the important species-specific behaviours of
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exploration and natural foraging, they are not without their welfare issues (Edwards et al., 2014). High amongst these is the exposure to climatic extremes, which in different seasons may subject the animals to extreme cold with freezing of water supply, extreme heat with risk of sunburn, or extreme rainfall with muddy underfoot conditions and lack of dry resting areas (Edwards, 2005). To counter these challenges, the provision of appropriate shelter is essential. For cold or wet weather this needs to allow the animal to access a dry, draught-free microclimate for rest, usually provided by a weatherproof structure with plentiful bedding such as straw. Such shelter is particularly important for farrowing sows, as their newborn piglets are very susceptible to cold stress. To counter high temperatures, the provision of shade from the radiant heat of the sun is very important as the thin hair coat of pigs makes them very susceptible to sunburn. The provision of muddy areas also allows them to express their natural behaviour of wallowing to coat the skin with wet mud, promoting evaporative cooling and leaving a protective layer of sunscreen.

A second area of welfare challenge for outdoor pigs relates to biosecurity and the maintenance of health (Delsart et al., 2020). Disease agents (those for African Swine Fever and Salmonella being topical examples) can be carried by wild animals and birds, whose ingress into open pig areas is difficult to prevent. Many of the endemic diseases seen in intensive indoor farming (for example, enzootic pneumonia) may be less prevalent in outdoor conditions due to decreased animal density. However, if an animal does become sick it is more challenging for stockpeople to detect this at an early stage and to catch and restrain an individual animal for treatment. Suffering due to untreated health problems is therefore a significant welfare risk in extensive systems. A particular issue for outdoor animals is infestation with parasites, which can survive for extended periods in the environment and set up a cycle of continuous reinfection. Regular antiparasitic treatment can control the level of infestation, although such an intervention is restricted in organic production and frequent movement to fresh uncontaminated pasture is consequently very important. Similarly, the build-up of disease agents inside farrowing huts which might infect vulnerable piglets can be minimised by relocation of the huts between each farrowing and removal or burning of old bedding.

A third area of welfare challenge is that of predation (Pietrosemoli and Tang, 2020). Whilst in many parts of the world exposure to large carnivores is rare, small carnivores such as foxes can prey upon piglets and, by disturbing farrowing sows, can also increase the risk of neonatal crushing. Scavenging and predatory birds can inflict pecking damage or even carry off small piglets venturing into exposed open areas.

A final area worthy of mention is that of the limitations which can be inadvertently or deliberately imposed on behavioural freedom. Although it may appear that many behaviours are possible in extensive conditions, their expression may be constrained by unregulated social competition or human intervention. Thus, access to resources may be difficult for low-ranking animals if they can be guarded by a more dominant individual. For example, if the size of the shelter provided is too small or the entrance poorly designed, or if food is not distributed over a sufficiently wide area, the more timid individuals within a group may suffer both fear and deprivation. Behavioural restriction may also be deliberately imposed by the contentious human intervention of nose-ringing to prevent rooting behaviour (Horrell et al., 2001). This is a highly motivated behaviour of pigs, but can cause extensive damage to pasture, giving rise to bare, overturned ground in a very short time when stocking density is high. Such paddocks can rapidly become a sea of mud in wet weather, giving poor living conditions for the animals and poor working conditions for stockpeople. This removal of vegetation also results in detrimental consequences for environmental pollution and for production from the following crop. These include soil compaction and increased loss of nutrients through gaseous emissions from the unprotected surface and leaching in rainwater, with consequent eutrophication of nearby
watercourses. Since nose-ringing causes both acute pain and chronic behavioural frustration, the balance of the different welfare and environmental harms needs to be carefully considered in each individual situation.

**Intensive farming systems**

When farmed pigs are kept indoors, they are subject to much greater control over all aspects of their life. This can have welfare benefits, since they can be provided with a carefully regulated and balanced diet, a controlled thermal environment, biosecurity measures to minimise risk of disease ingress and easy treatment of sick individuals. However, since the animals now have little autonomy in behavioural choices, the correct delivery of all these benefits is dependent on the management and husbandry skills of the humans in control. In subsistence farming situations, the necessary resources for optimal provision may be lacking, whilst in small hobby or part-time farms, human skills may be lacking through poor knowledge or limited experience. Benefits should be better realised as pig production enterprises become more professional but, as farms become ever larger, the ability to recruit, train, and retain good staff can again be a serious limitation on welfare. To overcome labour shortage and reduce cost, modern farms increasingly seek to automate many of the processes necessary to rear pigs. Whilst automation can reduce the need for many heavy and routine jobs, such as climate control, feed and water provision, and manure removal, it cannot yet replace the skilled stockperson for rapid problem detection and solution. A high reliance on automation leads to serious problems in many animals when breakdowns occur. Furthermore, when many animals are looked after by few people, they may have insufficient time to give adequate attention to all individuals, leading to increased suffering associated with undetected problems. The continual market pressure on pig farmers to produce cheap meat has resulted in widespread adoption of genetic, housing, and management innovations that increase financial efficiency. This can be beneficial for welfare, as animals which are in good health and without stress will be most biologically productive (Edwards et al., 2006). However, there are also many situations that bring profitability into conflict with animal welfare.

**Space restriction in breeding sows**

Perhaps the greatest area of welfare concern in intensive housing is the minimisation of expensive building space and the consequent restriction of movement to which animals are subject. This is most pronounced in the case of the breeding sow, where the desire to make efficient use of space while ensuring each animal received its own feed ration and preventing injurious aggression between animals led to the widespread adoption of individual gestation stalls. Whilst these deliver their specific production and welfare objectives, they impose great physical and behavioural restrictions on the sow (Marchant-Forde, 2009). The lack of movement weakens bones and muscles, and unstimulated sows may develop characteristics of apathy or depression. Most noticeably, the prevention of motivated foraging behaviours can result in behavioural abnormalities which develop into stereotypies such as bar biting and sham chewing. This problem is particularly severe in the case of the gestating sow, since she is normally fed a concentrate diet at a level which is optimal for good health and production but does not induce satiety. In consequence, foraging behaviours are induced but cannot be functionally expressed in restrictive stall housing, resulting in a situation where anomalous oral behaviours can become channelled into a neural pathology (Lawrence and Terlouw, 1993). Whilst some alleviating measures can be introduced in stalled conditions, by providing foraging substrate to permit more appropriate behavioural expression or increasing dietary fibre to promote satiety (Meunier-Salaun et al., 2001), this gives only a partial solution. In consequence, a growing number of countries have
now implemented legislation to ban or restrict the use of gestation stalls. Exemptions are often given for the first month of gestation, on the basis that this allows a recovery period for sows in poor body condition after lactation, provides protection during the oestrus period to weak sows which might otherwise be injured by the riding activity of bigger animals, and protects sows from social competition stress during the critical implantation period when developing embryos may be adversely affected. However, as knowledge and experience on the optimal management for group-housed sows increases (Spoolder et al., 2009), such exemptions are now being questioned.

A second period when close confinement is still widespread, but being increasingly questioned, is for the farrowing sow (Baxter and Edwards, 2021). Newborn piglets are very vulnerable, with crushing and hypothermia as major contributory causes to the typical mortality levels of 10–15% in the first days after birth. Confinement of the sow in a farrowing crate limits her movement and slows dangerous posture changes which might crush piglets and cause injury or death. Confinement of the sow also allows the provision of supplementary heating close to the birth site and allows safe access to the newborn piglets for stockperson tasks. These considerations have become increasingly important as genetic selection of modern sows for prolificacy has resulted in greater numbers of piglets born in a litter, with individual piglets being less physiologically mature and therefore more susceptible. Despite these production and welfare benefits for piglets, the farrowing crate does impose significant welfare detriments to the sow. Foremost amongst these is the prevention of proper expression of nest building behaviour. In the days prior to farrowing, a sow in the wild will wander widely while seeking a suitable nest site, and then gather branches and grasses and arrange these into a nest in which to give birth. Effective nest construction has a high survival value in these circumstances, and the associated behaviours have been genetically conserved and are triggered by the hormonal changes preceding parturition. Inability to express these behaviours, due to physical restriction and lack of substrate, induces frustration and stress in the sow which may be detrimental to the farrowing process and subsequent maternal behaviour (Yun and Valros, 2015). Furthermore, as lactation proceeds, normal interaction between the sow and her litter is hindered by the farrowing crate and the sow is unable to escape the increasingly importuning piglets. This can be stressful for the sow and hinders the natural behavioural process of gradual weaning for the piglets. In consequence, the abrupt early weaning which now predominates in commercial practice is much more stressful for piglets (Edwards et al., 2020). Attempts to develop alternatives to the farrowing crate which can increase behavioural freedom for the sow whilst safeguarding piglet survival have proved challenging for economic or other reasons. The imposition of temporary crating for only the farrowing period and a few days thereafter, before allowing greater space for the sow in an individual or group pen, can often give benefits for both welfare and performance, although the problem of frustrated nest building still remains. A few countries have implemented legislation to ban the farrowing crate and have developed appropriate management solutions to still operate successfully. Stimulated by current political pressure, research programmes are now developing and testing new pen designs (Baxter and Edwards, 2021). However, it is evident that these will only succeed when accompanied by appropriate genetic and stockperson inputs, and any concurrent increase in litter size from selection for hyperprolific sows will continue to pose major problems.

**Social living in restricted space**

Lack of space is not just a welfare issue in individual confinement, but also poses a challenge for group living. In the wild, pigs live in stable family groups which have access to widely spread resources. In contrast, group composition in farms is often of uniform age structure and changed
by remixing during the life of the pig, while resources are more localised. Pigs will compete aggressively to establish dominance when encountering new individuals. This usually poses only minor injury risk if there is space to flee, but it can result in more severe injury or even death in older and heavier animals (Marchant-Forde and Marchant-Forde, 2005). Whilst strategies to minimise aggression at mixing exist, they are seldom fully effective and are infrequently adopted in practice (Peden et al., 2018). Maintaining animals in stable groups for as much of their life as possible is the best strategy. This can be difficult when adopting group-housing systems for sows, as they must be regrouped at weaning to ensure contemporary batches and efficient use of space. The alternative housing strategy of large dynamic groups involves regular addition and removal of animals. In this situation, designing partitioned resting areas to accommodate sub-grouping behaviour can assist with gradual integration (Marchant-Forde, 2009). In growing pigs, keeping litters together throughout their lives, whilst behaviourally desirable, is inconsistent with achieving efficient use of pen space and matching feed specifications to pig weight. For this reason, pigs are frequently regrouped into weight matched pens when weaned at 3–5 weeks of age. Pigs in the wild integrate with other litters at about two weeks of age with relatively little aggression, and allowing co-mingling of suckling piglets can reduce their fighting after weaning. However, repeated subsequent mixing is detrimental to both welfare and performance (Peden et al., 2018).

Even in stable groups, aggression can be triggered by competition for resources. Space is an important resource, as pigs need sufficient space to rest undisturbed, to carry out their normal range of behaviours whilst avoiding encounters with aggressive dominants, and to show the signals of submission which avert attack (EFSA, 2005). However, the most important sources of aggressive competition are those associated with resources critical for survival – food and water. Whilst pigs are usually given continuous access to water, inadequacy in the location and number of drinking places, or the flow rate of water delivery, can result in frustration and aggression (Turner et al., 1999). Competition for food is generally the most potent source of aggression. When the amount of food is restricted and provided in discrete daily meals, dominant animals will aggressively displace subordinates and monopolise the feed supply. This is especially problematic in groups of pregnant sows, where the volume of feed provided is small relative to their appetite and a degree of chronic hunger is always present. To allow adequate feed intake by subordinate animals, very wide distribution of feed is the minimum preventative strategy, but protected individual feeding facilities are preferable to ensure equitable feed intake with minimal aggression. These may be provided by lockable individual feeding stalls or computer controlled individual feeding stations (Marchant-Forde, 2009). The latter system allows automated individual recognition and rationing, but requires animals to feed sequentially and must therefore have well-designed gating systems to prevent aggression at entry and exit points. Rearing pigs are also sometimes restricted in feed, but usually at a much less severe level than pregnant sows as the production objective is to achieve fast growth. However, any restriction on access to feed still represents a potential source of aggression and good design of feeding facilities is necessary (Manteca and Edwards, 2009). Where food is rationed, it must be provided in long troughs which allow all animals to eat simultaneously. This requires a trough length of at least 10% more than the combined shoulder width of the pigs, while the provision of head partitions preventing lateral movement gives further benefit. It is most common for growing pigs, especially younger ones, to be fed *ad libitum* (“at will”), with food always present in a dispenser. In this situation they can feed in turn throughout the day and many pigs can theoretically share a single feeding place. However, the existence of diurnal rhythms of activity, and of social facilitation which stimulates animals to feed simultaneously, mean that feeding space is not used with full efficiency. As a result, lower ranking individuals may still have suboptimal access despite theoretically adequate provision, and frustration can cause increased aggression.
Thermal and physical comfort

When animals are maintained in indoor conditions with limited space, another challenge is the maintenance of hygiene. Pigs in the wild will spatially separate their areas for resting, feeding and excretion. However, at high stocking density this becomes impossible and fouling of the resting area will occur. To maintain pen hygiene in these conditions, the keeping of pigs on fully or partially slatted flooring is very common (EFSA, 2005). This offers the welfare benefits of good drainage to maintain dry flooring and of separating pigs from their faeces and urine to reduce infectious challenge. However, other welfare implications of the use of slatted flooring are less positive, since pigs often show a preference for lying on solid floors. In fact, it may be that many other properties of the floor are viewed as more important by the pig (Ducreux et al., 2002). Pigs are very temperature-sensitive and will choose flooring with appropriate thermal characteristics which aid them to conserve or lose heat. Thus, in cold conditions they will seek insulating bedding or thermally resistant flooring, will lie in sternal posture with minimal floor contact and will huddle together to conserve heat. In hot conditions, they will seek heat conducting floors, lie in lateral recumbency to maximise surface area for heat loss and look for wet areas where they can wallow to increase evaporative cooling. In pens where these possibilities are absent, they will wallow in their own excreta as the only cooling option. Such pen fouling will also increase ammonia emission and give impaired air quality, which can cause irritation of the eyes and respiratory tract and exacerbate respiratory diseases in both pigs and stockpeople. Strategies for water misting or cooling the floor surface in hot ambient conditions are therefore beneficial for welfare (Opderbeck et al., 2020).

The nature of flooring is also very important for the physical well-being of the pigs (KilBride et al., 2009). Inadequately designed or maintained flooring is a major cause of injury, particularly lameness caused by physical damage to the legs and claws and exacerbated by associated ingress of infectious agents. Slatted flooring can be injurious when the surface area of the slat is too narrow to support the weight of the pig without causing excessive pressure on the sole of the foot, or when the void area is too large so that claws or dew claws are trapped between slats and twisted or torn. Sharp or abrasive edges to the slats result in even more severe penetrative injuries. Solid floors can also be injurious if rough and abrasive, causing claw and skin lesions when moving or changing posture, or very smooth and slippery, increasing the risk of falling and twisting joints during locomotion or vigorous social interaction (EFSA, 2005). In sows, deep-bedded flooring or lack of exercise may lead to lameness from hoof overgrowth due to lack of wear. Hoof disorders in breeding animals, which result in gait abnormality, discomfort, reduced mobility, and production loss, can be remedied by hoof trimming, although this is seldom a routine practice in sow herds (Tinkle et al., 2017). Hard flooring can also cause pressure injuries during prolonged lying. Adventitious bursitis is characterised by a fluid filled swelling which develops when pressure on lymphatic vessels and capillaries causes trauma. In more severe cases, these swellings may become infected or lesioned and develop into deep ulcers. In growing pigs, the most common locations to observe such pressure injuries are around the hock. They occur with high prevalence when pigs are kept on unbedded and slatted flooring (KilBride et al., 2009) and, whilst they seldom cause clinical problems or apparent pain, the extent to which they are associated with discomfort during resting on hard floors is uncertain. A more severe manifestation of a pressure injury associated with hard flooring is seen in the development of deeply ulcerated lesions on the shoulder in lactating sows (Rioja-Lang et al., 2018). These are more likely to develop in situations where poor body condition reduces the cushioning fat layer over the bony prominence of the scapula, or where ill health or lameness increases the time spent in lateral recumbency. The pain associated with such lesions is likely to depend on their degree of severity, and the extent of any associated local or systemic infection.
Barren environments

Another consideration of very great significance if pigs are kept on slatted flooring for liquid manure handling is the inability to provide substrate on the ground for bedding or enrichment. Whilst bedding can aid thermal and physical comfort, these needs can be alleviated by appropriate environmental temperature control and floor choice. However, bedding, even if sparse, also provides a substrate for exploration and foraging behaviours. These behaviours, involving rooting, chewing, and oral manipulation, have had an important evolutionary function and are genetically engrained in pigs (Studnitz et al., 2007). Pigs in the wild can spend more than 50% of daylight hours in such activities, which continue even when they are fully fed. If the pen provides no appropriate substrate for their expression, the behaviours may be redirected to inappropriate pen components or to other animals in the group. This can lead to serious adverse outcomes as discussed below. In part-slatted pens, small amounts of chopped straw or similar material can be provided daily on the solid area without too much risk of entering the slurry and disrupting the function of automated pumping systems. In fully slatted pens, substrate can be offered from racks or foraging towers, but to reduce cost and minimise labour demand it is more common to offer alternative enrichment in the form of balls or hanging items such as wood, plastic toys, or chains. These often fail to incorporate the desirable characteristics for sustaining pig interest (EC, 2016). Items provided on the floor soon become soiled, while even hanging items rapidly lose attraction as the pigs become habituated to them. Changing items frequently can help to maintain pig interest, but it is items which are easily destructible and thus need more frequent replacement which provide the most sustained occupation.

One of the reasons that enrichment is considered so important for pig welfare is that inadequate provision, which fails to satisfy the need for foraging and exploration, can lead to the damaging behaviour of tail biting (Valros, 2018). This is a behaviour which occurs widely in growing pigs of all ages, in which the tail may initially be gently chewed before progressing to more vigorous biting, drawing blood and developing into cannibalism of tissue extending up into the spinal cord. Once blood is present, other pigs are attracted and also develop the behaviour, until an uncontrolable outbreak spreads across the whole group, giving rise to serious injury and even death. Whilst the motivational basis for such behaviour is still poorly understood, it is now apparent that different forms of onset can be observed (Taylor et al., 2010). The causation is also highly multifactorial and more than 80 different risk factors have been identified, including barren housing conditions, nutritional inadequacy, thermal discomfort, frustration arising from social competition, genetic predisposition, and poor health. Other injurious behaviours of ear biting and flank biting may also occur and, while less well studied, are believed to share some of the same causal factors.

Harmful human interventions

For reasons of production enhancement or avoidance of undesirable behaviours with detrimental outcomes for animal welfare, a number of invasive procedures are commonly carried out on farmed pigs. These may be applied in all farming systems but tend to be more common in intensive production. One group of these are often referred to collectively as mutilations or piglet processing (Prunier et al., 2020). They are usually carried out in the first days of life, when the piglet is small and easy to handle, although the reasons for doing them may relate to much later events. The first procedure is tooth resection. Newborn piglets will compete aggressively for the best teats until a stable teat order is formed in the first day of life and, if the settled teat order is subsequently disrupted due to a shortage of milk or to cross-fostering of piglets between litters, this competition will be rekindled. To aid them in procuring and defending a teat, piglets are
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born with sharp incisor and canine teeth, which can inflict serious wounds on the faces of littermates, cause lesions and discomfort to the udder of the sow, and disturb nursing. To prevent such consequences, it is common to remove the upper portion of these teeth by clipping or grinding. It is uncertain to what extent this causes the piglet pain if done with care, as behavioural and physiological indicators have proved inconsistent. However, molecular markers do suggest pain from both resection methods, while incorrectly applied procedures can cause splintering of the teeth, gum damage, and provide a route for infection. It is therefore recommended that tooth resection is selectively applied only when high-risk litters are identified and it can be justified by a welfare balance.

A second procedure commonly performed in the first week of life is docking of the piglet’s tail, typically removing between one and two-thirds of the tail using clippers or thermal cautery. This is done to reduce the risk of injury from tail biting in later life, as it has been demonstrated that a short tail is less likely to be bitten. However, cutting of the tail is usually done without anaesthetic and has been demonstrated to be acutely painful to the piglet. There is also evidence to suggest the possibility of long-term pain from the amputated tail stump, although this is less certain (Prunier et al., 2020). Many farmers believe that, given the current inability to reliably prevent tail biting outbreaks, the harms of early life docking are much less than those from serious biting lesions in later life, and that the procedure is therefore justified. However, others contend that it merely absolves the farmer from addressing the root causes of tail biting problems, which are in themselves welfare problems for the animal (Valros, 2018).

A third type of procedure which may be done in young piglets, or sometimes later in life, relates to animal identification. Young piglets may be identified by ear notching, ear tattooing or the insertion of ear tags. The insertion of ear tags may also be carried out when pigs are older, since breeding animals need to be individually identified for efficient record keeping, or may need an ear tag transponder for electronic feeding systems. Finally, pigs require identification of farm of origin when transported for slaughter. This is usually done by slap marking to give a shoulder tattoo shortly before leaving the farm. All of these identification procedures are again carried out without pain relief and, whilst less severe than other interventions, do cause some short-term pain and handling stress to the pig (Prunier et al., 2020).

Finally, the most painful of the surgical interventions is the castration of male animals. Whilst a few countries produce pigmeat from entire males, this carries the risk of boar taint – an unpleasant odour and taste associated with compounds resulting from production of male sex hormones once the animal reaches puberty. The risk of taint increases as the animal ages and, since slaughtering at a young age is economically (and environmentally) undesirable, it is commercially preferable to castrate male piglets. There are also welfare considerations which promote this practice. Since many traditional breeds show puberty at a young age, unplanned breeding among finishing pigs can be a problem. Furthermore, entire male pigs at puberty will show increased aggression and riding behaviour which can cause disruption within the group and injury to recipient animals. Historically, the castration of male piglets has been done in the first week of life by surgical removal of the testes without anaesthesia or analgesia (Prunier et al., 2020). More recently, concerns about the very significant short- and medium-term pain associated with this process have led to the requirement in a growing number of countries to provide some pain relief and to seek alternatives causing less welfare detriment. One such alternative, in situations where rearing entire males is deemed impractical, is the use of immunocastration (Borell et al., 2020). This involves immunisation against the endogenous gonadotrophin releasing hormone (GnRH) of the pig using a “vaccine”, typically given as two injections with an interval of at least four weeks and with the second dose given four to six weeks prior to slaughter. With this procedure, the animal assumes the characteristics of a castrate only after the
second injection, giving the production benefits of an efficient entire male in early life, but the subsequent behavioural and meat quality benefits of a castrate. The stress from the handling and injection procedures in older pigs would seem preferable in comparison to the pain of surgical castration, but consumer concerns about pharmacological interventions in food producing animals have limited acceptance of this technology in some markets.

In the drive to alleviate welfare problems without need to employ invasive procedures such as those described above, genetic selection tools are being increasingly explored (Rydhmer, 2021). The pig industry has very effectively harnessed the power of genetic selection over many decades to improve production traits. The development of specialist international breeding companies has facilitated selection within large pig populations using sophisticated statistical tools to make simultaneous genetic progress in desirable production traits such as growth rate, feed efficiency, carcass leanness, and sow prolificacy. Such intense focus on high production has sometimes resulted in undesirable side effects, such as increased risk of skeletal, cardiovascular, and immunological impairment in very fast-growing young animals, or increased risk of neonatal compromise and mortality in very prolific sows (Knap and Rauw, 2009). However, health and welfare traits are now receiving much more attention, with exploration of possibilities to select for disease resistance, robustness, low boar taint and good maternal behaviour, and select against aggressiveness and tail-biting predisposition. Whilst of lower heritability than many of the previous production traits, this possibility is now aided by the increasing use of genomic selection tools.

In the longer term, genetic selection may negate the need for other pharmaceutical interventions to improve growth. Whilst exogenous hormones are not used commercially for growth promotion in pigs, some countries outside the EU routinely use beta-agonists which direct the nutrients from food to muscle growth rather than fat deposition, and thus improve economic efficiency and carcass leanness. The physiological effects of these agents have led some to question the welfare implications of their routine use, although few detrimental effects at appropriate dose levels under good management have been proven (Ritter et al., 2017). The prophylactic use of in-feed antibiotics to reduce disease risk and enhance growth, especially in newly weaned pigs, is still widespread in many countries. However, increasing consumer concern about the risk of development of antibiotic resistance within the human food chain, in combination with concern that prophylactic antibiotics may be used to mask other animal welfare problems, has seen the banning or restriction of their use in a growing number of countries or market outlets (de Briyne et al., 2020), and this trend seems likely to continue.

**Monitoring and assuring good pig welfare**

Historically, it was the empathy that carers have for their animals and their professional pride that motivated attention to the welfare of farm animals. In many situations, this still pertains and is of paramount importance. However, in some cases, cruelty, ignorance, or the profit motive may still result in welfare impairment. To guard against such situations, legislation has been enacted in many countries and, as a result of societal concern, is increasing in detail and scope. A more recent development is the emergence of Farm Assurance schemes, driven by the market, which require farms to operate according to specified standards or codes of practice exceeding legal requirements. Both legislation and farm assurance have generally focussed on production systems and the specification of resource requirements. Whilst these provide important safeguards against known environmental risks, they often fail to adequately consider the important influences of management and husbandry across diverse farming systems. Ultimately, it is the welfare outcome for each individual animal which is of importance, and ways in which this might be objectively assessed using animal-based measures are receiving increasing emphasis. Initiatives
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Table 6.1 Animal-based measures which can be used to indicate the welfare state of farmed pigs (modified from Welfare Quality®, 2009, with further additions). Welfare Quality® measures have standardised assessment protocols, but other measures can provide useful indications during stockperson inspections.

<table>
<thead>
<tr>
<th>Welfare principles</th>
<th>Welfare criteria</th>
<th>Animal-based assessment measures</th>
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<tbody>
<tr>
<td>Good feeding</td>
<td>Absence of prolonged hunger</td>
<td>Body condition score, stereotyped oral behaviours, competition at feeding points</td>
</tr>
<tr>
<td></td>
<td>Absence of prolonged thirst</td>
<td>Competition at drinking points</td>
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<tr>
<td>Good housing</td>
<td>Comfort around resting</td>
<td>Bursitis, shoulder sores, skin cleanliness</td>
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<tr>
<td></td>
<td>Thermal comfort</td>
<td>Lying posture, panting, skin soiling, shivering, huddling</td>
</tr>
<tr>
<td></td>
<td>Ease of movement</td>
<td>Gait score, slipping</td>
</tr>
<tr>
<td>Good health</td>
<td>Absence of injuries</td>
<td>Lameness, body wounds, tail lesions, ear lesions, vulva lesions</td>
</tr>
<tr>
<td></td>
<td>Absence of disease</td>
<td>Coughing, sneezing, laboured breathing, faecal consistency, hernia, prolapse, signs of inflammation (swellings), and infection (discharges)</td>
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<tr>
<td></td>
<td>Absence of pain induced by management procedures</td>
<td>Docked tails, resected teeth, removed testicles, nose ring, injection abscesses</td>
</tr>
<tr>
<td>Appropriate behaviour</td>
<td>Expression of social behaviours</td>
<td>Skin lesions from aggression, wounds from repetitive massage</td>
</tr>
<tr>
<td></td>
<td>Expression of other behaviours</td>
<td>Stereotyped behaviour, interaction with enrichment</td>
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<tr>
<td></td>
<td>Good human–animal relationship</td>
<td>Approach/withdrawal response to humans</td>
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<tr>
<td></td>
<td>Positive emotional state</td>
<td>Play behaviour, Qualitative Behaviour Assessment</td>
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such as the EU Welfare Quality® project have developed animal-based measures for pigs to inform observers about each of the domains of welfare (Table 6.1). These approaches are now being translated into practical farm assessment protocols for pigs (Pandolfi et al., 2017). Such initiatives are likely to be facilitated in the future by the increasingly sophisticated surveillance tools being developed for farms and abattoirs in Precision Livestock Farming.

No consideration of animal welfare in any production system is complete without consideration of the day-to-day practicalities of human–animal interactions, the benefits of positive interactions and the management of compromised individuals (Hemsworth and Coleman, 2010). Inconsiderate handling makes pigs fearful and induces chronic stress. The provision of appropriate handling facilities for moving and restraining pigs is therefore essential for low-stress operation. The optimal design for raceways, crushes, and loading ramps is well researched (Grandin, 2007), and the monitoring of handling practice by such simple outcome measures as the frequency of distress vocalisations can be very revealing. Further benefits, particularly in breeding animals, can be given by engaging in regular positive interaction, such as brief stroking and gentle speech, which produces quieter and more productive animals. Finally, it must be acknowledged that in any biological system illness and injury will occur in some individuals. The rapid identification of such compromised individuals and appropriate treatment, including pain relief when required, is essential. This necessitates provision of appropriate hospital accommodation where their particular needs for physical and thermal comfort, access to feed and
water and protection from social challenge can be ensured. A rapid and objective decision on their response to treatment and their current and future quality of life is necessary, and humane euthanasia should be promptly applied if required.

Conclusions

Pigs can be farmed in many different systems, each of which brings its own set of risks to animal welfare. The level of risk is greater in intensive production systems, where pigs have less autonomy to exercise their innate behavioural predispositions and deal with welfare challenges. Good management and husbandry are therefore essential to identify and control these risks or to alleviate their welfare consequences. To aid in this task and demonstrate successful achievement of good welfare, the assessment of animal-based measures of welfare outcome for all individuals in the population provides an important tool.

References


Farming pigs


