THE WELFARE OF BROILER CHICKENS IN THE EU

From science to action

EUROGROUP FOR ANIMALS

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PREFACE

Meat chickens (broilers) are the most numerous terrestrial farmed animals in the European Union (EU). They are predominantly reared indoors in intensive farming systems. EU legislation includes minimum rules for the protection of chickens kept for meat production (Directive 2007/43/EC) and the main provision of this Directive aims to limit high industrial stocking densities, viewed by many as the main contributor to poor welfare (Estevez, 2007). However, arguably the Broiler Directive does not go far enough to ensure bird welfare and, in fact, a study by the European Commission on the implementation of this Directive (EC, 2017) acknowledges that ten years from its entry into force it is still not possible to draw any definitive conclusions on the impact that this law has had on the welfare of broiler chickens.

While broiler chicken welfare has been on the agenda of animal welfare advocacy organisations for a long time, only recently does there appear to be real momentum on this issue, which is likely to have a positive and long-lasting impact on the life of broilers. In some EU Member States, the various supply chain stakeholders have worked together to jointly agree on higher welfare standards that aim to eliminate the worst aspects of intensive industrial rearing systems for broiler chickens (e.g., high stocking density, fast growth, barren housing conditions). This reflects a global movement whereby major retailers and food businesses have committed to work towards sourcing broiler chicken meat from production systems with higher welfare features[1, 2] with target dates around 2026. These commitments hold the potential to positively impact bird welfare as they include lower stocking densities (without derogations), the use of slower-growing breeds and enhanced daily living environment with enrichment, such as foraging and pecking objects. The EU Farm to Fork strategy includes in its scope the revision of all animal welfare legislation. There is much scope to include better protection for broiler chickens.

The main aims of this document are

1. to summarise scientific findings on the welfare challenges that broiler chickens face during all stages of their life, including those not currently addressed by minimum legal requirements, such as the breeding phase and the welfare of broiler chicks after hatching.

2. to highlight the potential solutions, with an emphasis on the role that higher welfare broiler chicken production can play in addressing the most pressing issues. Welfare risks for chickens have several origins: there are risks related to their genetics, risks related to the design of the housing facilities, while others are related to management practices. Each chapter in this report explains different aspects of these risks from a scientific perspective. Awareness of how these can be mitigated should assist stakeholders such as policy makers and industry actors to ensure the highest level of welfare for broilers in all phases of their life.

1 https://welfarecommitments.com/europeletter/

2 https://betterchickencommitment.com/

This report is divided in three sections: the first section concisely presents the legislation in place that affects broiler welfare. The subsequent chapters present and discuss the welfare of broiler chickens during the three phases of their lives that are covered by EU legislation: rearing (growing), during transport and at the time of slaughter. These chapters highlight the key issues for welfare and discuss how some of these issues can be mitigated.

The second section deals with aspects for which species-specific norms do not apply, with the exclusion of Directive 98/58/EC (Farm Animals Directive). Chapter 4 provides an extensive overview of the welfare of the parent animals that produce the broiler chickens that are reared for meat. This is not a well-known part of the chicken meat industry and there are several welfare risks for these birds.

Chapter 5 examines the main welfare challenges of newly hatched chicks and how these can be mitigated in commercial hatcheries and on-farm, primarily by means of technological innovations.

The last section looks into the future. Chapter 6 deals with the welfare of higher welfare, slower-growing broiler chickens in various rearing systems. Chapter 7 reviews the current state of knowledge on sustainability, describes the market forces driving change in this sector, and makes the case for the importance of integrity along the whole supply chain. Finally, in Chapter 8 we summarise the animal advocacy perspective on the importance of transitioning towards a higher-welfare broiler chicken industry.

The Annex presents EU and extra-EU market data on broiler chicken production and trade.

SECTION 1

EU LEGISLATION ESTABLISHING MINIMUM STANDARDS FOR THE PROTECTION OF BROILER CHICKEN WELFARE

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In the EU, the production of chicken meat is regulated by several legislative tools, namely Regulations and Directives. The Council Directive 2007/43/EC (Broiler Directive), together with the Council Directive 98/58/EC (General Farm Animals Directive), form the legislative basis for the protection of broiler chickens in the EU.

In 2007, the EU decided that it was "necessary to establish rules at Community level for the protection of chickens kept for meat production" (Dir. 2007/43/EC, recital 6). This decision followed a report of the Scientific Committee on Animal Health and Animal Welfare (SCAHAW, 2000) on the welfare of broiler chickens. Based on the conclusions of the SCAHAW report, the Directive states that "the fast growth rate of current broiler strains is not accompanied by a satisfactory level of welfare including health" and that "the negative effects of high stocking rates are reduced in buildings where good indoor climatic conditions can be sustained (Directive 2007/43/EC, recital 4)".

The Broiler Directive entered into force in 2010, it applies to holdings with more than 500 birds[3] and sets the minimum rules with which producers must comply in order to protect broiler chickens kept for meat production in the EU. In this legislative text there are provisions concerning the housing of the birds, standards for drinkers, feeding, litter, ventilation, noise, light (artificial), and requirements for inspections (Dir. 2007/43/EC, Annex I). However, ten years from the Directive's entry into force, it is still not possible to draw clear conclusions on its impact on the welfare of the animals that it set out to protect. Indeed, a

3 Broiler chickens kept in holdings with fewer than 500 birds are protected by the General Farm Directive.

study released by the European Commission on the implementation of this Directive (EC, 2017) lacks such assessment. In this report, the European Commission acknowledges that the Directive has been implemented differently across EU Member States, and this may have impeded the assessment on its impact on the welfare of the animals. Additionally, it should be noted that the Directive *per se* does not include such provisions which have the potential to positively impact the quality of life of broiler chickens. For example, there is no obligation for their keepers to provide the birds with enrichment materials, access to natural light, access to outdoors or covered outdoor areas. Absent also are measures to minimise the impact of health issues related to the selection for fast growth as well as measures addressing the welfare risks for broiler chicken breeding birds (parent stock)[4].

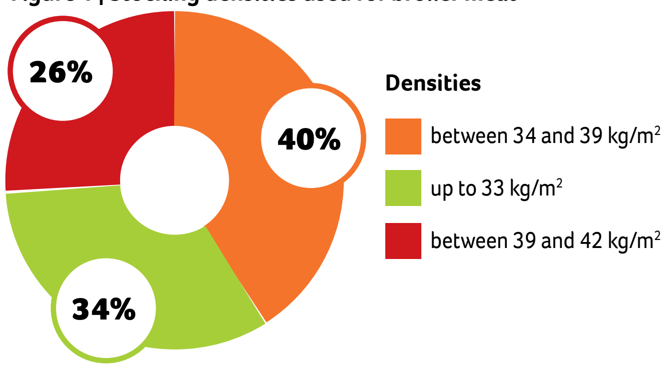
While it is widely acknowledged that high stocking densities play a major role in broiler chicken welfare (SCAHAW, 2000; Estevez, 2007), the legislative provisions on stocking density are particularly relevant. Despite the fact the Broiler Directive specifies a maximum stocking density of 33kg/m^2 (Dir. 2007/43/EC, Art. 3.2), it is possible, by meeting a number of additional criteria, to keep birds at a stocking density of 42kg/m^2 (Dir. 2007/43/EC, Annex II) which results in 25 birds (of 2kg each) per square metre (SCAHAW, 2000).

Overall, only 34% of the total number of broiler chickens raised in the EU are kept below the minimum stocking density set by the Broiler Directive (Figure 1).

Other EU legislation relates to broiler chickens raised in alternative systems (i.e. extensive indoor, free-range and organic production). For alternative and organic farming systems, Commission Regulation (EC) No 543/2008 (Marketing Standards Regulation) and Council Regulation (EC) No 834/2007 (Organic Regulation) apply. However, it must be noted that the standards that may affect welfare as specified in these two regulations are not mandatory *per se*, but only apply in relation to the selling of poultry meat under specific labels[5].

Council Regulation 1099/2009 (Slaughter Regulation) and Council Regulation 1/2005 (Transport Regulation) apply to the slaughter and transport of animals, including broiler chickens[6]. The Transport Regulation prohibits the transport of animals that are not fit for the intended journey (Reg. 1/2005, Annex I, Chapter I), and prohibits transport that is likely to cause injury or suffering (Reg. 1/2005, Recital 11). It also requires that livestock hauliers obtain certificates of competence (Reg. 1/2005, Art. 6.5). Additionally, specific space allowances are provided with the aim of preserving the welfare of poultry transported alive (Reg. 1/2005, Annex I, Chapter VII (E)). Despite the fact that the criteria and potential reasons for the definition of maximum journey times for livestock travelling to slaughter have been proposed and discussed in the past years, this subject has received little attention in relation to the transportation of poultry (EFSA, 2011) and no maximum journey time for poultry is currently set by EU transport rules. Recital 9 of the Regulation refers to specific provisions for poultry transport to be set up at the release of opinions by the European Food Safety Authority (EFSA), but specific proposals on this topic have not yet been put forward.

Figure 1 | Stocking densities used for broiler meat



production in EU-28 Member States. Proportion of national broiler chicken flocks, data from 2017 from competent authorities. Source: European Commission, 2017.

To protect the welfare of the animals, including poultry, at time of killing, a series of provisions are laid down in the Slaughter Regulation. This legislative text defines specific requirements for the restraint of poultry before stunning (Reg. 1099/2009, Art.15) as well as a list of stunning and killing methods (Reg. 1099/2009, Annex I). In case of slaughter following religious practices, the derogation to mandatory stunning also applies to poultry (Reg. 1099/2009, Art. 4.4).

[4] See Chapter 1 "Designing the right environment for broiler chickens during rearing" of the present Report.

[5] 'Extensive indoor' ('Barn-reared'); 'Free range'; 'Traditional free range'; 'Free range - total freedom'; 'Organic'.

[6] See Chapter 2 "Broiler chicken welfare during pre-slaughter transport", and Chapter 3 "Animal welfare during the stunning process of poultry" of the present Report.

In the EU, there are also environmental rules that apply to broiler chicken meat production:

- Under Directive 2010/75/EU (Industrial Emissions Directive) all poultry farms with more than 40,000 birds are required to hold an environmental permit;
- Under Directive 2011/92/EU (Environmental Impact Assessment Directive) all poultry farms with more than 85,000 birds need to perform an environmental impact assessment (EIA);
- Directive 2001/81/EC (National Emission Ceilings Directive) gives limits for ammonia emissions for every Member State. On top of this, certain EU Member States have additional regulations to reduce ammonia emissions from poultry farms, such as the Netherlands and Germany (Van Horne, 2018);
- Directive 91/676/EEC (Nitrates Directive), whose primary scope is to protect water quality by controlling pollution caused by nitrates coming from the agricultural sector. Particularly, the Directive's main focus is the management of animal manure.

In upcoming years, changes in the EU legislative framework, relevant to the welfare of broiler chickens, are likely to be adopted. In May 2020, the European Commission announced the revision of the Transport Regulation and the Slaughter Regulation, in the framework of the EU Farm to Fork Strategy. As a part of this strategy, the European Commission will carry out a fitness check on the EU animal legislation, including the Broiler Directive and the General Farm Animals Directive. The aim is to assess the relevance, effectiveness, scientific appropriateness, coherence and implementation of these legislative texts.

The EU is also promoting and supporting scientific research on the welfare of broiler chickens. At the beginning of 2020, the *ad-hoc* EU Reference Centre on Animal Welfare (EURCAW) - established under the Commission Implementing Regulation (EU) 2019/1685 and led by the Agence nationale de sécurité sanitaire de l'alimentation, del'environnement et du travail (ANSES) - started working on the welfare of broiler chickens on farms and at the time of slaughter. Finally, the scientific outcomes of the centre, as well as the recommendations made by EFSA on the slaughter (EFSA, 2019a) and killing of poultry (EFSA, 2019b), are expected to be considered in the legislative revision process.

1.
DESIGNING THE RIGHT ENVIRONMENT FOR BROILER CHICKENS DURING REARING

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Chicken is one of the world's most consumed meats, and the European Union has a significant stake in this industry, producing over 12 million tonnes of chicken in 2017[7]. While broiler rearing systems are typically viewed as being highly uniform in nature, in reality there are a variety of production systems in operation. These range from free-range systems that use slower-growing birds to unenriched total confinement (or 'indoor') systems where fast-growing birds are used. There is also a myriad of 'enhanced' indoor systems in operation, typically providing more space and environmental enrichment to meet retailer or quality assurance requirements for broiler welfare.

Farm animal welfare is important to EU citizens[8], and there is evidence of particular concern about the welfare of poultry[9]. There is a belief that having access to outdoor space contributes positively to the welfare of broiler chickens (de Jong and van Trijp, 2013; Vanhonacker et al., 2016), but this type of production is still relatively niche. The majority of broiler chickens in the EU are actually reared indoors and the focus of this chapter is on ways to improve their welfare within such systems.

[7] Source: FAO Stat.

[8] European Commission (2016) Special Eurobarometer 442/Wave EB84.4: Attitudes of Europeans towards Animal Welfare.

[9] European Commission (2005) Special Eurobarometer 229 (2)/Wave 63.2: Attitudes of consumers towards the welfare of farmed animals.

1.1
GENETICS

Broiler chickens in indoor systems are typically bred to reach slaughter weight at 5 to 6 weeks of age, and the rapid growth rates have been linked to increases in metabolic disorders, leg health issues and mortality (see Bessei, 2006, and EFSA, 2010). Fast growth rates also appear to contribute to increasing inactivity in the birds as they get older, and this may further compound some health issues. In fact, studies show that fast-growing broilers spend a significant majority of their time sitting/lying towards the end of the production cycle (Weeks et al., 2000; McLean et al., 2002). As a result of these issues there is increasing interest in the use of breed types with slower growth rates, and, in fact, this is one of the key areas of focus in the European Chicken Commitment[10], which is gathering momentum. The use of slower-growing breeds within sustainable production systems is discussed in more detail in Chapter 6.

1.2
GROUP SIZE AND STOCKING DENSITY

Broiler chickens are typically reared in groups of tens of thousands of birds in large houses bedded with litter, and with ready access to feed and water. Under natural conditions chickens exist in much smaller social groups where it is possible to recognise their group-mates. Within very large group systems where individual recognition does not appear possible (Appleby et al., 2004), further increases in group size (for example from 20,000 to 40,000 birds in a house) may not exacerbate social stress. What is likely to be more important from an animal welfare perspective is the degree to which individual access to resources such as feed, water, floor space and enrichment is maintained as group size increases. In addition, the ability of farmers to adequately check all birds and to maintain appropriate levels of air and litter quality in very large groups is likely to be key from an animal welfare perspective.

Stocking density (typically expressed as kg of bird per m^2 of floor space) is perhaps a more contentious issue, as it obviously directly relates to how many birds can be reared simultaneously within a given house. It is also

recognised as a specific area of concern to consumers (de Jong and van Trijp, 2013). Evaluation of the effects of stocking density should ideally be conducted under commercial conditions so that findings are realistic and translatable to the poultry industry. Dawkins et al. (2004) evaluated five different target stocking densities (30, 34, 38, 42 and 46kg/m^2) on farms in a trial involving 2.7 million birds. They found that **higher stocking densities can have adverse effects on both growth rates (production problem) and gait scores (animal welfare problem).** Bailie et al. (2018b) also investigated the effects of stocking density on the welfare of birds on commercial farms. They assessed target stocking densities (30, 32, 34 and 36kg/m^2) in windowed houses and found a significant increase in the severity of foot pad dermatitis when stocking density increased from 30kg/m^2 to 34 or 36kg/m^2. Studies conducted under experimental conditions also indicate potential adverse effects of increasing stocking density. For example, McLean et al. (2002) found an increase in deep panting behaviour (indicative of thermal discomfort) towards the end of the production cycle in broilers housed at target stocking densities of 34 and 40kg/m^2 compared to those housed at 28kg/m^2.

Under Council Directive 2007/43/EC farmers can stock birds up to a maximum of 42kg/m^2 provided that certain conditions are met. **Collectively, the studies highlighted above indicate that using space allowances at the higher end of the permissible EU limit is a risk factor for reduced welfare. The effects of higher stocking densities on broiler welfare include difficulty in dissipating heat, reduced litter quality, and physical restriction of movement.**

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10 https://welfarecommitments.com/europeletter/

1.3
VENTILATION AND LIGHT

A well-functioning ventilation system is key to broiler welfare in terms of preventing heat stress and maintaining litter and air quality. This is particularly important given the level of water consumed and heat produced by modern broilers. For example, Thaxton et al. (2016) refer to evidence that metabolic heat in broilers has increased 30% in the last 20 years, and that water consumption has almost doubled during the last 25 years. If litter becomes too wet, then this contributes to problems with contact dermatitis on the footpad and hock. The large on-farm study by Dawkins et al. (2004) that was discussed above emphasised the importance of litter and air quality, and indicated that the quality of the on-farm environment created by farmers had a greater effect on broiler welfare than the space allowance provided.

Light is also an important aspect of a chicken's environment. Under current EU legislation (Directive 2007/43/EC), chickens must be provided with light of an intensity of at least 20 lux during the light periods, illuminating at least 80% of the usable area in the house. For most of the production cycle, farmers must ensure that the light cycle follows a diurnal pattern with 6 hours of darkness (and at least 4 hours of uninterrupted darkness) in each 24-hour period. This must be provided within 7 days of chicks being placed in the house and until three days before the foreseen time of slaughter. Therefore, a longer photoperiod can be provided at certain periods of the production cycle in the EU, and with young chicks it is suggested that this might help them to locate food and other resources in the house. There are concerns, however, about the welfare effects of near constant daylight on broilers (Schwean-Lardner et al., 2016). Trials conducted under experimental conditions (where different photoperiods were applied from 7 days of age) suggest that **darkness periods of 7-8 hours are optimal for broiler welfare** (Schwean-Lardner et al., 2012; Schwean-Lardner et al., 2013). However, optimum photoperiods for broilers of different ages and breed types when housed under commercial conditions are currently unclear.

The source of light also appears to have a significant impact on the welfare of broilers. Chickens evolved in natural light conditions and this typically differs from artificial light in a number of ways, including in terms of light intensity and quality. Birds see further into the ultraviolet spectrum (UV) than humans (Appleby et al., 2004), and it is thought that low light intensity and/or lack of UV wavelengths in artificial light contribute to low activity levels. This suggests that it would be beneficial to rear indoor broilers in windowed rather than windowless houses, and, in fact, this is supported by a large on-farm trial involving 368,000 birds by Bailie et al. (2013). This study showed that **providing access to natural light through windows led to a number of benefits, including:**

- An increase in light intensity and presence of UV light in the broiler house
- A significant increase in broiler activity levels
- An improvement in leg health measures
- An improvement in litter quality
- No adverse effects on growth performance

Other recent research supports these findings in terms of showing beneficial effects of providing environmental enrichment in combination with natural light on walking, exploration and foraging behaviour in commercially housed broilers (de Jong and Gunnink, 2019).

These findings help to underpin an increased move by the industry to install windows in broiler houses on welfare grounds. In fact, providing windows in houses is now recommended (and will become compulsory) as part of the Red Tractor Food Assurance Scheme.[11] There are legitimate concerns, however, that temperature regulation within windowed houses may be difficult in very warm climates. Knowledge gaps appear to exist in this area, in particular in relation to optimum number and positioning of windows, optimum type and positioning of glass within windows, and effects of strategic use of blinds/shutters.

[11] Assured Food Standards (AFS), Red Tractor Assurance, Chicken Standards: Broilers and Poussin v4.2, 2019.

1.4
ENVIRONMENTAL ENRICHMENT ITEMS

Of key concern is the ability of farmed animals to perform natural, species-specific behaviours. One way to achieve that and also to promote more general activity within indoor systems is to provide appropriate environmental enrichment items. While provision of environmental enrichment is stipulated in current EU pig welfare legislation, this is not the case with broiler chicken legislation. The reasons for this are not clear, but it perhaps reflects the shorter production cycle in broilers, or the lack of significant harmful social behaviours in broiler chickens (such as tail biting in pigs).

Despite the lack of EU legislation, we often see requirements to provide items such as straw bales, pecking objects and perches in commercial broiler houses as part of high welfare quality assurance schemes. These enrichments are intended to facilitate/stimulate more natural behaviour patterns in broilers and therefore are a positive move, but it is important to ensure that they have a tangible effect on welfare rather than just contributing to a better aesthetic in the house.

Perches. Although poultry are no longer at risk of predation in indoor systems, they remain motivated to find an elevated and secure place to rest. However, changes to the conformation of broilers associated with fast growth rates appear to have limited their use of traditional 'bar' perches. As a result, despite perching being an important natural behaviour, use of bar perches has been reported to be low on commercial broiler farms. This is in contrast to the situation with laying hens where high levels of usage of 'bar' perches have been shown at night on commercial farms (Brendler and Schrader, 2016).

More recently, researchers performed preference tests to ascertain which type of perch broilers would prefer to use. Bailie et al. (2018a) offered commercially housed birds access to one of six different perch types and monitored levels of use across the production cycle. The perches offered to the birds included standard bar perches, swinging bar perches, ramps, suspended platforms and different designs offering a combination of ramps, bars and platforms.

The broilers showed a clear preference for perching on platforms and this preference was evident across the production cycle. Norring et al. (2016) also observed greater levels of use of elevated platforms by broilers than of a bar type perch. Slower-growing broilers, which have not been under the same selection pressures, may not display the same preferences (Fig.1.1). However, where fast-growing broilers are used, evidence suggests that they should be provided with platforms for perching. Kaukonen et al. (2016) also showed improved leg health in broilers provided with platform perches

Figure 1.1 | Broilers are motivated to perch. Use of a standard bar-type perch (as shown here) may prove difficult for breeds with fast growth rates and platform perches may therefore be more beneficial. Image copyright: RSPCA.

compared to birds without perches, and suggested this may have been due to increased opportunities for more versatile movement. More recently, research by Bach et al. (2019) indicates that elevated platforms are also relatively effective in promoting comfort behaviours in broilers, providing further evidence of positive effects on welfare. There are knowledge gaps, however, on the broader behavioural effects of providing broilers with raised platforms for perching (Riber et al., 2018).

'Exploratory/Foraging' enrichments. Environmental enrichment regimes are often designed to facilitate natural exploratory and foraging behaviour, and thus also to promote general activity. The motivation to actively forage for food may be different between broiler chickens and laying hens, and it should not be assumed that something that stimulates this type of behaviour in laying hens will do the same with broilers.

ARE STRAW BALES A GOOD FORM OF ENVIRONMENT ENRICHMENT FOR BROILERS?

It is clear that broiler chickens dismantle short-cut straw bales quite effectively when provided in commercial houses, suggesting that they engage well with this form of enrichment. When provided at high levels (e.g. one bale per 17m^2 of floor space), straw bales also increased overall activity levels in commercially housed broilers (Kells et al., 2001). However, this effect may not be found if bales are provided at typical commercial levels (e.g. Bailie et al., 2013, where one bale per 44m^2 of floor space was provided). Broiler chickens may have additional uses for straw bales as they appear to perceive them as a form of shelter/protection with as many as 30 birds seen to cluster around each bale on farms (Baxter et al., 2018b). Vertical panels placed within houses also appear to provide perceived protection and can be placed strategically to achieve a more homogenous distribution of birds in the house (see Riber et al., 2018). The dismantling of straw bales by chickens can also have a positive effect on the quality of litter in houses. **This multifunctional role played by straw bales suggests that they should form part of an environmental enrichment regime for broiler chickens (Fig.1.2).**

Figure 1.2 | **Straw bales can serve many functions in commercial broiler houses such as facilitating exploratory/ foraging behaviour, acting as a perching substrate, providing perceived protection and improving litter quality. Image copyright: RSPCA.**

WHAT ABOUT PECKING OBJECTS?

These include point source enrichments intended to stimulate pecking behaviour, such as chains or strings. Although there does not appear to be evidence of strong and consistent effects of these types of enrichments on activity levels or leg health in commercially housed broilers (Bailie and O'Connell, 2015), they are used by the birds at quite a high level and therefore appear to have a value in facilitating natural pecking and exploratory behaviour. For example, recent research by Baxter and O'Connell (2019) showed an average of 70 pecks directed at lengths of plastic chain during 10-minute observation periods in commercial broiler houses, suggesting more interest in this type of enrichment than previously thought. At present, some quality assurance schemes suggest that at least one pecking object per 1,000 birds should be provided. It is not clear if this provides sufficient access to pecking objects and both the nature of the pecking object, and the level provided, require further investigation.

Figure 1.3 | **The chicken at the centre of this image is carrying out dustbathing in a clean substrate. Broiler chickens show distinct preferences for dustbathing substrates; providing appropriate substrates in commercial houses has been shown to improve leg health. Note that the blue markings in this picture are non-toxic and for research purposes. Image copyright: RSPCA.**

Dustbathing areas. Dustbathing is a natural, highly-motivated behaviour in poultry that may be used to help maintain feather condition. The type and quality of litter available in commercial broiler houses influences the possibility to perform this behaviour. Therefore, creating discrete dustbathing areas might be beneficial (Fig.1.3). We know from recent work that broilers have distinct preferences for dustbathing substrates, for example preferring to dustbathe in peat or oat hulls (a by-product of the milling industry) than in wood shavings or straw pellets (Baxter et al., 2018a). We also know that this type of behaviour actually increases as broilers get older while many other active behaviours decline.

Follow-on research by Baxter et al. (2018b) investigated the individual and combined effects of providing straw bales and oat hull dustbathing areas in commercial broiler houses (22,000 birds per house). The results showed a high level of engagement with both types of enrichment, and, again, an increase in dustbathing behaviour each week between 3 and 6 weeks of age. In addition, significant positive effects on leg health (in terms of improved gait scores) were also shown at the end of the production cycle when dustbathing areas were provided. This is an important finding, indicating that it is possible to improve leg health through provision of the right type of physical enrichment material in commercial broiler houses. This effect might have reflected the fact that dustbathing behaviour involves significant leg movement to kick dirt over the feathers and therefore may have strengthened legs. These results indicate that **providing appropriate dustbathing substrates should form part of environmental enrichment programmes in commercial broiler houses.**

Level and arrangement of enrichment within houses. Although high welfare quality assurance schemes typically specify levels of enrichment to be provided (e.g. 2m perch space per 1,000 birds), there has been very limited applied research in this field. This is essential in order to provide a strong evidence base for enrichment provision and policy advice.

Given the scale of house size typically used, the ideal arrangement of environmental enrichment items within broiler houses is also worth considering. There have been suggestions that it might be beneficial to create discrete "activity areas" where enrichment items are grouped together, to facilitate cross-usage of different enrichment types and to enable other areas of the house to be more clearly demarcated for rest. Baxter and O'Connell (2019) investigated the effects of creating clusters of enrichment items in commercial broiler houses (including dust baths, straw bales and pecking objects) compared with providing the same enrichment items separately in different areas of the house. The same overall level of enrichment items was provided in each case, and the provision of enrichment items in 'activity clusters' did not appear to promote increased engagement. This is clearly an area that warrants further research, and potential effects of different strategies on both use of the enrichment and also on litter quality should be considered.

1.5
HOW CAN WE TELL IF WE ARE PROVIDING THE RIGHT ENVIRONMENT?

It seems reasonable to suggest that the right environment for farm animals is one that enables them to achieve, at the very least, a life worth living (and, ideally, a good life). This concept, outlined by the Farm Animal Welfare Council[12], indicates that, although not sufficient in itself, "… the balance of an animal's experiences must be positive over its lifetime". **This requires production systems that not only provide for the physiological and mental needs of animals, but also for certain wants that are important determinants of quality of life.** This may include facilitating natural behaviours and providing appropriate space and environmental stimuli in broiler systems can help in this respect.

Like most farm animal systems, broiler production is complex, and many factors interact to affect welfare outcomes. **It is vital that outcomes are monitored on an ongoing basis across the production cycle. This should not only include monitoring negative welfare outcomes such as lameness, but also indicators of positive experience such as engagement with environmental enrichment and play behaviour.** Directly monitoring level of engagement with enrichment items also helps in determining if there are any problems with their provision, for example perches being too high or too much plastic covering being left on straw bales. The high ratio of chickens to animal caretakers suggests that we should also look to technology to assist with ongoing welfare monitoring. Vision-based technologies and deep learning approaches offer enormous opportunities in this respect.

[12] Farm Animal Welfare Council (2009). Farm Animal Welfare in Great Britain: Past, Present and Future. London, FAWC.

CONCLUSIONS

Chickens contribute significantly to the commercial agri-food sector in Europe, and play a major role globally in sustaining smallholder producers. They **are naturally an active, inquisitive species and we owe it to them to understand what they require in commercial housed systems.** The research presented in this chapter strongly suggests that **attention should not only focus on the *amount* of space typically provided to broiler chickens in housed systems, but also on the *quality* of that space.**

Lighting schedules and source of light, in addition to effective ventilation systems, play an important role in determining the quality of space provided to broiler chickens. **Environmental enrichment** programmes are also important in enhancing the quality of space. The young age and genetic make-up of broiler chickens mean that their needs are different to those of other poultry, and we cannot simply assume that environmental enrichment strategies that work with laying hens will also work with commercial broilers. Motivational approaches such as preference tests therefore offer useful tools in designing 'bespoke' environments for broilers and have been successful in helping us to determine optimum perch types and dustbathing substrates. Providing these preferred enrichments on commercial broiler farms has also been shown to lead to improved leg health, and therefore they should be considered in environmental enrichment programmes. **Enrichment items such as straw bales can serve multiple functions** (in terms of facilitating natural exploratory/foraging behaviour, providing shelter and maintaining litter quality) and therefore should also be considered. **Broilers also show interest in pecking objects**, but knowledge gaps remain in relation to their broader welfare benefits. In general, however, **the body of scientific evidence showing welfare benefits associated with appropriate environmental enrichment strategies for broiler chickens is growing and should be used to underpin enhanced legislation in this area.**

2.
BROILER CHICKEN WELFARE DURING PRE-SLAUGHTER TRANSPORT

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The last phase of a broiler chicken's life before slaughter can be called the pre-slaughter phase. This phase contains several procedures leading up to the actual process of stunning (i.e., rendering the animals unconscious and insensible) and slaughter. This chapter describes what happens in the pre-slaughter phase. When broiler chickens reach the desired body weight, birds are taken off feed, caught, loaded into transport containers or crates, transported in trucks, unloaded and kept in lairage (waiting area), removed from transport containers, stunned and shackled (the order of these last three steps depends on the stunning method, see Chapter 3), and slaughtered.

Although relatively short, this phase (from feed withdrawal on the farm up until the start of stunning/slaughter), contains many stressors and risks for animal welfare. Most research on this topic shows evidence of acute stress (with stress hormones such as corticosterone as an indicator), physical injury, and mortality in response to this phase. Yet other welfare concerns are likely to occur, such as aversion to handling and the vibrations of the truck (Abeyesinghe et al., 2001). These stressors and risks can lead to fear, acute and chronic stress, pain, injuries, thirst and hunger, weight loss, plumage soiling, thermal discomfort, or death (thus determining the proportion of birds that arrive dead at the slaughterhouse, also called DOAs, Dead on Arrival). In this chapter, four major risks are presented and discussed.

2.1
THE BIRD'S CONDITION OR FITNESS IN THE PRE-SLAUGHTER PHASE

The physical condition of broiler chickens before the start of the pre-slaughter phase plays an important role in how they will experience the stressors associated with this phase (Caffrey et al. 2017). First of all, male broilers and broilers with both relatively low or high body weights are more likely to die during the pre-slaughter phase ('death-on-arrival' or DOA) (Nijdam et al., 2004; Haslam et al., 2008; Chauvin et al., 2011). Slaughter weights may depend on the intermediary buyer (e.g. a food processor or retailer), with common live weights between 1.9kg and 3.5kg (Chauvin et al., 2011; Tuyttens et al., 2012; Kittelsen et al., 2017). Some hybrids or strains seem more sensitive to pre-slaughter stressors than others, which is reflected in the difference in DOA prevalence (Nijdam et al., 2004; Haslam et al., 2008). It is likely that birds that are in suboptimal physical condition prior to the start of the pre-slaughter phase will be less resistant to stressors than the clinically fit. Existing pathological conditions may exacerbate the impact of stressors during the pre-slaughter phase and predispose birds to die during this phase. This means that sick birds are more likely to die than healthy birds: for instance, infectious diseases such as laryngitis and tracheitis were found in 65% of the birds that died during the pre-slaughter phase (Nijdam et al., 2006).

Birds that were deemed unfit in an experimental trial due to stunted growth (or emaciation), lameness, or signs of disease (e.g. respiratory sounds, crouched posture) showed a stronger corticosterone response (acute stress) to transport and lairage when this occurred under high and low crating densities, compared to clinically fit birds (Jacobs et al., 2017c). This further supports the notion that the pre-slaughter phase can be more demanding for compromised individuals and indicates the need for individual fitness assessments, which is mandated by EU animal transport law (EC Regulation 1/2005). Annex I of this EU Regulation states that only fit animals may be transported, and that animals should only be transported if this does not cause them unnecessary injury or suffering. Animals are deemed fit for transport if they are able to move independently without pain, walk unassisted, and do not have a severe open wound. Animals that are sick or injured may be transported if this does not cause additional suffering. Applying this legislation to broiler chickens during transport requires individual assessment of fitness, as is common in large animal species. Two challenges arise:

1. Broiler chicken production involves thousands of animals within a single poultry house;

2. If an individual assessment were carried out, this would likely result in a large proportion of birds deemed unfit for transport, depending on the indicators that are considered.

Current flock sizes vary, ranging from 1,000 to 60,000 birds in the Netherlands (based on 1,907 flocks, Nijdam et al., 2004), 35,000 to 48,000 birds in Belgium (114 farms, Tuyttens, et al., 2012; 81 flocks, Jacobs, 2016), 11,000 to 25,000 birds in Norway (n=32 flocks, Kittelsen et al., 2017), and 1,400 to 47,000 birds in France (n=404 flocks, Lupo et al., 2008). Therefore, the current procedure for a fitness assessment entails a decision at flock level, with the producer/farmer signing a document declaring the fitness of the entire flock. It should be noted that practical guidelines for individual assessment exist (Consortium of the Animal Transport Guides Project, 2017; Jacobs et al. 2017d; Poultry Industry Council, 2017). However, **individual 'manual' assessment of fitness for transport is extremely time-consuming and therefore it is not done in practice during the pre-transport phase, which constitutes a breach of EU legislation on the protection of animals during transport.** To give an example, assuming it takes 5 seconds for an animal to be assessed (by a trained observer), it would take a total of 48 hours to check a flock of 35,000 birds (more than a full work week). Thus, alternatives (either automation or otherwise) need to be considered to ensure an appropriate level of individual animal welfare before transportation.

Considering the indicators for fitness from EU legislation (European Union, 2005), **lameness, injuries and disease should be the focus of pre-transport assessments.** Many individual birds may be unfit for transport, especially if any level of lameness is considered as an indicator of fitness. Lameness can be a prevalent welfare issue in broiler chickens, ranging from 15% to 31% of birds affected (Sanotra et al., 2003; Knowles et al., 2008). This highlights an animal welfare issue that is unrelated to the pre-slaughter phase (an existing condition), but one that could affect animal welfare in this final phase of production. If a hypothetical fitness assessment resulted in 15% to 31% of birds being deemed unfit for transport, the alternative for those

Figure 2.1 | **Chicken harvester – catching equipment – with a system of conveyor belts picking up the birds from the litter floor, moving them to the centre of the harvester, and loading them into transportation crates (Jacobs, 2016).**

birds should be carefully considered. Euthanasia on farm would be humane (recommended by the Consortium of the Animal Transport Guides Project, 2017), but from a sustainability – and economic – perspective this would cause an immense loss (5,000 to 10,000 birds in a single 35,000-bird flock). **On-farm slaughter of vulnerable birds is a good alternative to avoid transport. However, current legal constraints (European Union, 1993, 2005) make it a large investment for producers and therefore public financial support should be made available to producers willing to make such investments.**

Opportunities

Lameness, disease and injuries are major determinants of fitness. A fitness assessment could therefore be integrated with automated procedures such as catching with harvesters (mechanical equipment used to catch birds, rather than manual catching – see below) at point of catching. Some currently used harvesters determine crate stocking density based on the weights of the birds that are placed on the conveyor belt. These weights could be used as an indicator of fitness for birds with stunted growth or emaciation, and birds that may be too heavy, thus more at risk of dying during the pre-slaughter phase. The measuring of average bird weight could aid the automated selection procedure (e.g., birds that are 500g lighter or heavier are separated or marked as unfit for transport). Manual fitness assessments could be combined with daily checks the producer/farmer performs during production.

The post-mortem assessment of animal-based welfare indicators – which is foreseen by EU legislation for broilers, Directive 2007/43/CE – is possibly more feasible than individual assessment of fitness of live birds, under most conditions. These indicators can provide a retrospective insight into flock fitness, with whole-carcass rejections and DOAs routinely assessed in all slaughter plants. Additional assessment of injuries (fractures, dislocations, bruising, footpad dermatitis) on all birds would provide important animal welfare information and could likely be automated. Presently, some slaughter plants manually or automatically assess a sample of birds for bone fractures and other injuries, for instance in Belgium. On-farm slaughter and processing (allowed under Council Regulation (EC) 1099/2009[13]), is a possible method to limit animal welfare issues caused by the pre-slaughter phase for animals that are not in a physical state to undergo that stressor. However, the stressor associated with slaughter, including the novel environment, handling, shackling and inversion still could cause distress, fear and injuries.

[13] On farm killing is allowed for: emergency killing, killing for local supply, or depopulation for disease control.

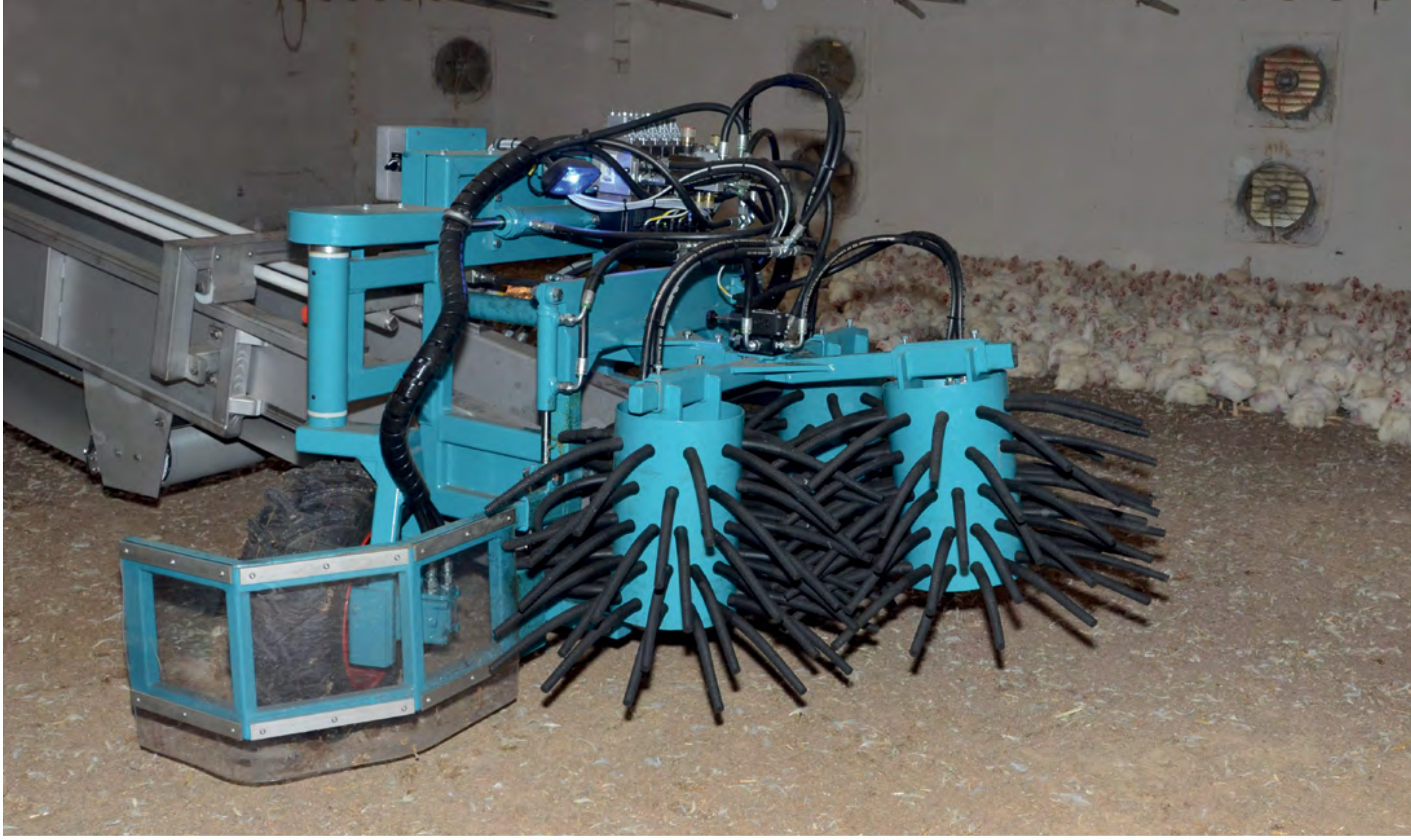

Figure 2.2 | **Chicken harvester – catching machine – with rotating rubber fingers to catch and lift birds from the litter floor. A conveyor belt moves the caught birds to the containers that are loaded onto the truck (photo courtesy of Peer System B.V.).**

2.2 HUMAN-ANIMAL INTERACTIONS

During the pre-slaughter phase, birds are handled more often compared to the grow-out (rearing) phase, where handling is uncommon (although daily human presence in the poultry house is normal). Birds need to be caught and loaded into transportation crates, which is often performed by contracted catching crews that enter the barn, catch birds by their legs, three to four at a time, and carry them inverted to the crates for a few metres (Bayliss and Hinton, 1990; Jacobs, 2016; Cockram and Dulal, 2018). Up to 12 people may be involved during the catching and loading of one or more flocks, and in some countries these catchers may be acquaintances of the producer, rather than specialised catching crews (Jacobs et al., 2017b). Before and in between catching bouts, birds may be 'herded' towards a certain area in the barn, to concentrate the number of birds within reach and limit the risk of forklift loaders injuring birds. Alternatively, birds are loaded by harvester equipment rather than being caught manually. These large harvesters, which can only be used in big poultry houses due to their size, use conveyor belts (Figure 2.1; e.g. Apollo, CMC Industries) or rotating 'rubber fingers' (Figure 2.2; e.g. Chicken Cat, JTT Conveying) to lift birds from the floor, and move them to a central conveyor belt that places birds into crates or containers (Knierim and Gocke, 2003). After a container is filled, it is moved onto the truck by a forklift loader. In addition to handling during the catching and loading stage, birds are handled again prior to slaughter. This aspect of handling will be covered in the next section.

Handling may cause fear, distress, injuries and death and **is a key issue during the pre-slaughter phase.** In addition to handling during the catching and loading stage, birds are exposed to noise, activity or agitation, environmental changes (change in temperatures, increased dust), social regrouping in crates, high stocking densities in crates, vibration and other aversive movements. Birds are most commonly caught and carried by one or two legs (upside down) during manual catching. Broilers show increased fearfulness and acute stress responses (corticosterone) after rough inverted handling compared to gentle, upright handling (Jones, 1992; Kannan and Mench, 1996).

THE IMPACT OF INVERTED CARRYING ON BROILER CHICKEN WELFARE

When birds are carried by their legs (Figure 2.3), two behavioural responses are likely; either they will show tonic immobility (a reaction whereby they 'freeze' their behaviour and become immobile), or they will show a reaction indicative of stress or aversion, such as wing flapping (Wolff et al., 2019) and vocalisations. Tonic immobility is a natural response for chickens, usually a bird's final response to the threat of a predator, although it can be misinterpreted to indicate a state of relaxation (McBride, 2017). This behavioural state can be induced by holding a bird upside down or laying it on its back and is used by scientists as a test for measuring fearfulness, with longer durations illustrative of birds experiencing more fear. Broilers that were held by their legs and inverted for 30 seconds (conventional catching method), showed tonic immobility durations of more than 11 minutes, compared to nearly 7 minutes for birds that were held upright and stroked for 30 seconds (Jones, 1992). These responses, and the fact that broilers are relatively small compared to other livestock, are theorized to be the main reasons that this type of handling and carrying is still widely accepted in the industry (Main and Hewson, 2012). Inverted shackling duration was also positively associated with acute stress responses (corticosterone levels) and fearfulness, meaning that longer durations were associated with a greater stress response and more fear (Bedanova et al., 2007).

Another welfare issue associated with inverted handling is related to the big breast muscles of broilers belonging to fast-growing breeds compared to other types of chickens (e.g., slower-growing breeds, laying hens or jungle fowl). Birds do not have a diaphragm and during inverted handling the pressure of the relatively heavy breast muscles of broiler chickens can burden their heart and lungs, which is likely uncomfortable and can be fatal. For the same reasons, so-called "turtle birds" – birds that end up lying on their back during grow-out/rearing or that were placed on their back in a transportation crate – will likely die if not turned onto their feet (Jacobs, 2016; Jacobs et al., 2017a).

In addition to stress, fear and aversion, rough treatment of broilers during catching can cause injuries such as bruising (Delezie et al., 2006), and fractures (0.8%, Kittelsen et al., 2015b). In one study, wing fracture prevalence increased from 0.1% to 1.9% after catching and loading compared to before (Jacobs, et al., 2017b). Bruising may be more frequent depending on the catching company involved, illustrating that some people may be rougher or differently trained than others (Nijdam et al., 2004, Jacobs et al., 2017b). Catching accounts for 11%-38% of bruises on breast, wings and legs (Reali, 1994, reported by Pilecco et al., 2013) and can cause back scratches, with flock prevalence of circa 15% (Pilecco et al., 2013).

Figure 2.3 | **The manual catching and crating of broiler chickens are high-risk events for injuries and bruises, including fractures. Image copyright: Jo-Anne McArthur/ WeAnimals.**

Human-animal interactions can result in DOAs. Choice of catching crew or catching method may affect mortality prevalence (Bayliss and Hinton, 1990; Ekstrand, 1998; Nijdam et al., 2005). An older study concluded that catching and transportation injuries were the cause of 35% of pre-slaughter mortality, and 40% was due to stress or suffocation (Bayliss and Hinton, 1990). More recent findings show that as many as 25% of DOA birds present some type of internal trauma, most commonly ruptured livers and fractures, which are likely the causes of death for those birds (Kittelsen et al., 2015a). Injuries and mortality are a major concern for animal welfare and even low prevalence should be avoided as it is a major concern for the individual birds involved. A recent review concluded that injury can occur at any moment during human-animal interaction, including during herding, catching, carrying, loading birds into containers, loading containers onto the truck, unloading of containers, and during removal of birds from crates or modules (Cockram and Dulal, 2018). A lack of economic incentives may be part of the issue. Catching crews are contracted by integrated poultry companies, and are paid based on the number of birds in a flock, rather than the hours worked. This may stimulate catchers to be quick, and possibly rough, to get the job done (same amount of birds in a shorter time period).

Opportunities

Differences between catching crews or companies indicate that **training (or personal attitudes) can play a role in bird welfare during human-animal interactions.** An opportunity to improve the situation could lie in more research on effective training methods, and the development of a validated training method, potentially standardised for all catching companies.

Previous work has indicated that a person's attitudes and beliefs affect their behaviour, thus, training to modify their beliefs and attitudes towards broiler chickens could theoretically change their catching behaviour. For example, people with positive beliefs about petting, verbal interaction and physical effort to handle cows, were less likely to show inappropriate behaviour such as pushes and hits when handling cows (Hemsworth et al., 2002). However, current industry training is more likely to involve skills-based aspects, including the transfer of technical knowledge (Coleman et al., 2000). For other species, cognitive and behavioural modification training has proven effective for stock people (Hemsworth et al., 1994; Coleman et al., 2000; Hemsworth et al., 2002). Hemsworth et al. (1994) found the training to successfully improve worker attitudes and reduce fearfulness in pigs, with the pigs spending more time near the experimenter compared to control farms. In line with these findings, training for catching crews could be similarly beneficial for animal welfare parameters. One study found that skills-based training for catching crews for four consecutive weeks resulted in reduced incidence of back scratches (Pilecco et al., 2013). Currently more research is needed on training of catching crews for better handling and the effects on broiler welfare. One limitation is that catching crews may not have a sense of ownership, which is more likely in stock people. Furthermore, labour turnaround, language and cultural differences could limit the effectiveness of training.

Alternative manual catching methods such as upright catching and abdomen catching (Kittelsen et al., 2018; Wolff et al., 2019) **have the potential to reduce welfare issues during the pre-slaughter phase.** Using mechanical harvesters is economically feasible for some producers, but animal welfare outcomes do not always suggest improvements (more DOAs compared to manual catching; Ekstrand, 1998; Delezie et al., 2006; Chauvin et al., 2011) and further research is needed to determine best practices.

Figure 2.4 | **A truck loaded with chickens in containers waits to leave the farm. During lairage and transport, chickens are at risk of suffering from heat and cold stress. Image credits: Jo-Anne McArthur/WeAnimals.**

2.3
THERMAL CONDITIONS

Conventional broiler chickens are genetically selected for their high metabolic rate, resulting in fast efficient growth. This high basal metabolic rate means these birds produce relatively more heat than other strains, and this makes them more sensitive to high environmental temperatures compared to low temperatures (Mitchell and Kettlewell, 2009). Transportation trucks generally do not have active climate control, exposing birds to ambient conditions (rain, wind, high and low temperatures). Accordingly, thermal stress is one of the major risk factors for DOAs (Bayliss and Hinton, 1990; Gregory and Austin, 1992).

Heat stress

Broiler chickens are transported in containers, which are stacked in trucks with passive ventilation (Figure 2.4). These trucks have tarps or curtains to protect birds from extreme weather conditions, and those tarps can be opened and closed. The thermal load to which birds are exposed is multifactorial, depending on environmental factors such as ambient temperature, humidity, stocking density, and curtain configuration on trucks, and animal-based welfare indicators, such as body weight, fully fed or fasted, feather coverage, and cleanliness. Thermal stress can be a welfare concern throughout the pre-slaughter phase but is most likely to occur when birds are crated in the truck, with the truck stationary while parked (in heat) or moving (in cold), depending on the ambient conditions. In addition, thermal stress can occur during lairage. Animal-based indicators of heat stress are panting (i.e. open-beak breathing, gular flutter[14], stretched neck, increased breathing frequency), increasing distance from other birds, separating and lowering wings from the body, and raised body temperature compared to the normal range, which is between 40.6˚C and 47.1˚C (Bestman et al., 2009).

Thermal stress in itself is a welfare concern, but it can also be associated with increased pre-slaughter mortality. There is a clear positive exponential relationship between DOAs and ambient temperatures (Warriss et al., 2005). Mortality rates in commercial flocks can be 30% higher with ambient temperatures between 17˚C and 19˚C compared to lower temperatures (between 0˚C and 16˚C) (Warriss et al., 2005). Their data suggested a critical maximum ambient temperature of about 17˚C for broilers, with DOA rates of approximately 0.10% below that threshold, and of 0.13% (at 17˚C to 20˚C) to 0.66% (at 23˚C to 27˚C) beyond that threshold.

[14] Gular fluttering cools the air in the mouth as it passes the wet parts of the mouth, cooling the air.

Cold stress

Although heat stress is the major concern for broiler chickens, cold stress can also occur (Knezacek et al., 2010; Burlinguette et al., 2012). Animal-based indicators for cold stress can be huddling, shivering, raising/fluffing feathers, and decreased body temperatures. In a Flemish study, 0.55% of birds were found huddling together in lairage, which indicates cold stress (Jacobs et al., 2017b). In the colder climate of Canada, large differences between in-crate temperatures were found during transportation, with crate temperatures ranging from 10˚C to 30˚C within the same journey, when the outdoor temperature was -7˚C (Knezacek et al., 2010). During those transports, it is likely that birds experienced cold stress indicated by decreased cloacal temperatures (Dadgar et al., 2010; Knezacek et al., 2010), while others experienced heat stress with possible associated mortality (e.g. Jacobs et al., 2017a). Indeed, a 'thermal core' was identified during winter transportation, showing that towards the front and top of the trailer, temperatures were significantly higher than towards the rear of the truck, if journey duration was long enough (Knezacek et al., 2010). This thermal core develops because truck curtains are closed, limiting airflow and thus increasing humidity within the truck.

Opportunities

Thermal stress is a major risk for bird welfare during the pre-slaughter phase. **An obvious strategy to minimise this risk is to limit bird exposure to weather conditions by using climate-controlled trucks or other cooling strategies.** Climate-controlled trucks require an initial investment, which makes other methods such as misting possibly more feasible while still effective. Improved animal welfare results in lower mortality (Warriss et al., 2005) and better product quality (e.g. Dadgar et al., 2010), which contribute to offsetting any initial investments required. Specialist animal transportation companies have developed climate-controlled lorries, in which ventilation and temperature are actively controlled and monitored. Those lorries have the capacity to transport 9,000 birds (or 18,000 kg) birds with mechanical ventilation and active temperature control (Figure 2.5). These lorries require adapted catching and loading systems with specific mechanical harvesters that load birds onto layers (floors) within the truck, rather than into containers or crates. Unloading and cleaning at the slaughter plant also requires specific equipment.

Another option is to schedule transports for days and/or times of day when heat and cold stress are less likely to occur, especially for flocks that may be more at risk. This requires careful planning (Ljungberg et al., 2007; Cockram and Dulal, 2018) and coordination with the slaughter plant, where order of arrival, body weight, salmonella status, crate stocking densities, and available slaughter lines all play a role in determining when flocks are processed (Lambrecht et al., in preparation). In addition to maintaining better control over the birds' thermal environment, **focusing production on more robust broiler strains can provide an alternative or complementary strategy to improve animal welfare and decrease DOAs.**

Figure 2.5 | Lorry with active ventilation and temperature monitoring. Birds are mechanically caught and loaded onto a single-layer shuttle, driven to the truck and loaded onto a single layer along the length of the trailer (photos courtesy of Peer System B.V.).

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2.4
LACK OF ROUTINE WELFARE MONITORING AND RECORDING

Pre-slaughter welfare status is to some extent monitored at the slaughter plant, yet outcomes are not structurally collected in a database and may not be communicated to involved stakeholders such as transporters or catching crews. A slaughter plant employee is designated to ensure appropriate welfare at the plant. EU legislation requires large-scale slaughter plants to employ an animal welfare officer assessing bird welfare status at arrival and unloading into the waiting area (lairage) and to do post-mortem checks (Council Regulation No. 1099/2009, art. 46). In other plants, veterinarians may be responsible for ensuring appropriate welfare on site.

Routinely monitored welfare data

Although steps are being taken to monitor broiler welfare status routinely, most assessments may just rely on visual inspection of birds in lairage without actual data recording, and data collection is often not standardised. Some indicators can provide insight into on-farm welfare status, such as footpad dermatitis, which is assessed in all EU Member States (Butterworth et al., 2016). Outcomes of this assessment can be routinely communicated to the producer. However, according to a recent report by the European Commission (2016), only approximately 20% of total EU broiler production (Denmark, Netherlands and United Kingdom) undergoes complete, effective assessment of on-farm welfare during post-mortem inspections at slaughterhouses. Thus, the remaining 80% of EU broilers are not routinely or effectively assessed for on-farm welfare. The report did not consider pre-slaughter welfare (European Union, 2016). **In the EU, wing fractures and DOAs are recorded routinely in 70% and 100% of the responding member states respectively** (Butterworth et al., 2016). These animal-based measures can provide retrospective insight into pre-slaughter welfare, but may not always be communicated to the producer, and probably never to the transporter or catching crew. **For both on-farm welfare and pre-slaughter welfare, there is a need for standardised assessments and appropriate thresholds for outcome-based indicators** (European Union, 2016).

Compared to the post-mortem phase, the welfare of broilers during the pre-slaughter phase is a somewhat neglected aspect in EU legislation and welfare assurance schemes alike. Welfare monitoring protocols and assurance schemes for broiler chickens mainly focus on the on-farm phase (e.g. Welfare Quality® Network, 2009). The RSPCA assurance scheme in the UK and the Better Life assurance scheme in the Netherlands do include a more detailed focus on the pre-slaughter phase (RSPCA, 2017; Dutch Society for the Protection of Animals, 2018). As part of a study in Belgium, a specific animal-based pre-slaughter welfare assessment protocol for broiler chickens was developed (Jacobs et al., 2017d). A consortium commissioned by DG SANTE has developed guidelines for best practices during live transport for different species, including poultry (Consortium of the Animal Transport Guides Project, 2017). Furthermore, current efforts are focussed on the integration of pre-slaughter welfare aspects in a welfare assessment protocol that would cover the complete production phase (de Jong, pers. com. October 2019).

Opportunities

The routine monitoring and recording of data in a harmonised format either locally or centrally would provide an opportunity to compare and benchmark pre-slaughter welfare status among flocks, catching crews, transporters, and slaughter plants. Post-mortem assessments at the slaughter plant provide a retrospective insight into the welfare of the animals (and management on farm), thus providing an opportunity for animal welfare improvements in subsequent flocks. As multiple flocks are transported to the plant each day, assessments in one location are time-efficient, cost-efficient and reduce biosecurity risks. A retrospective fitness-for-transport assessment including injuries, disease (whole-carcass rejections) and DOAs would be valuable, especially if data are stored and routinely shared within the industry for benchmarking.

Automated animal welfare outcome assessment would allow further improvements through objective observations, increased sampling sizes (for instance the whole flock rather than a sample of 100 birds) and limited risks for human error if the automated methodology is properly validated. Some slaughterhouses have already incorporated devices to automatically score footpad dermatitis, an indicator of on-farm welfare, through video imaging techniques. In this case, software is able to identify foot lesion severity based on the size of the lesion, and will apply a score to a bird based on the worst footpad as well as a total score for the whole flock (Meyn, 2019). Similar approaches could be adopted for other welfare indicators such as fractures, dislocations and bruising, for which in some cases automatic grading is already used to distribute carcasses to certain processing sections (e.g., 'whole carcass' for good quality carcasses, 'cut up' for damaged carcasses). Other stimuli for welfare improvements could be to use CCTV for monitoring and continuous improvement of animal handling, and the use of incentives or penalties for performance on key welfare indicators. This type of monitoring is already required by some higher-welfare farm assurance schemes. Both of these approaches could be applied throughout the pre-slaughter phase, including catching crews and transporters. For instance, providing monetary incentives to producers for 'good quality products' successfully reduced footpad dermatitis prevalence from 60% in 2002 to 10% in 2012 in Denmark (European Union, 2016). Furthermore, stocking density allowances are based on these footpad dermatitis scores, providing an additional incentive to keep the prevalence low. A similar approach based on the prevalence of fractures or bruises could be effective in improving the performance of catching crews.

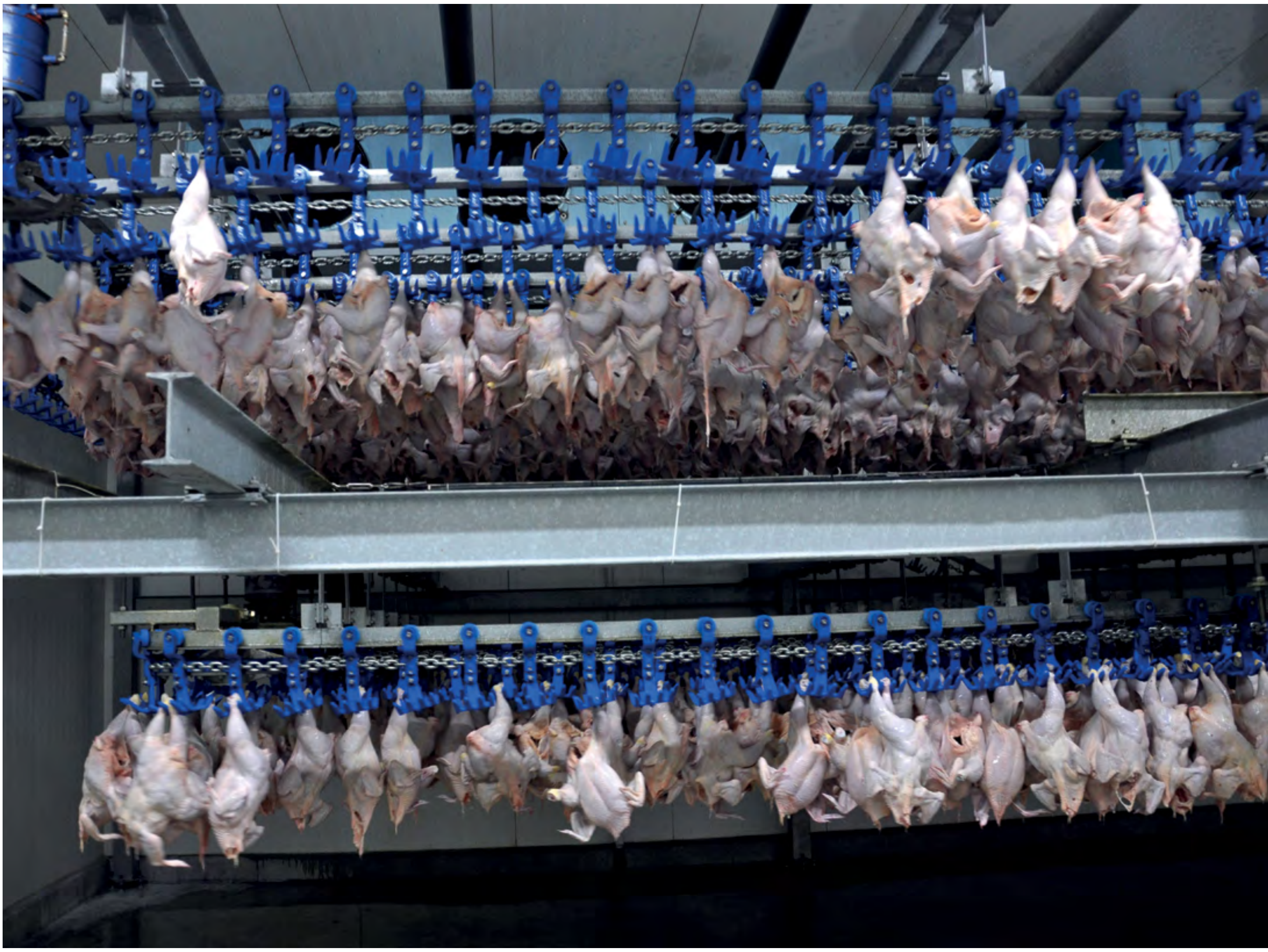
CONCLUSIONS

Preventing the deterioration of animal welfare during the pre-slaughter phase requires a series of steps. There is a need for individual fitness assessment prior to the start of the pre-slaughter phase, as some birds are more at risk of welfare impairment than others. Yet, currently the 'manual' assessment of all birds in a flock is not done due to time constraints. Future research into automated fitness assessments needs to be performed to address this issue. Thereafter, the question of what to do with the unfit animals, which may be a large proportion of a flock depending on welfare indicators assessed, needs to be answered. **On-farm slaughter and processing are feasible and potentially animal welfare friendlier alternatives**. Therefore, **dedicated public funding should be made available to producers willing to invest in on-farm slaughter and processing. There is currently no evidence that it is possible to transport compromised or vulnerable birds in a way that does not cause further pain or suffering (hence complying with EU law).**

Human-animal interactions are a major risk for animal welfare during the pre-slaughter phase, with fear, stress, aversion, injuries and death as possible consequences. Effective training of catching staff may contribute to minimising some of these risks, but **economic incentives are needed for catching crews to improve their methods, attitudes and approaches.** Thermal stress has for a long time been identified as one of three major risks to animal welfare during transport, but effective solutions have not yet been widely adopted. **Climate-controlled trucks should be used to prevent heat or cold stress while birds are in the truck.** A similar approach (climate-controlled space) is deemed good practice during lairage (Consortium of the Animal Transport Guides Project, 2017).

The **systematic assessment and centralised recording of animal-based welfare indicators at the slaughter plant would allow for better enforcement of EU legislation,** the benchmarking of farms **and**, ultimately, **large-scale improvements for animal welfare.** Automating these assessments is key to limit costs and ensure objective assessments.

3.
ANIMAL WELFARE DURING THE STUNNING PROCESS OF POULTRY



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This chapter discusses the different events that happen to broiler chickens in the slaughterhouse, starting with the end of the waiting time in the lairage area (see also Chapter 2). The birds are handled, either individually or picked up in their transport container, to be moved to the area where they are stunned. Subsequently, their necks are cut ('bleeding' phase) to ensure death, and finally their carcasses are moved to a tank with boiling water to remove the feathers ('scalding tank'). There are welfare risks in all the steps in this process, linked to different stunning systems, which are discussed in this chapter.

Figure 3.1 | **Example of containers for broiler chickens used for transporting them to the slaughterhouse. The type and design of these containers influence the risk of animals being injured during handling. Sharp edges and small openings must be avoided. The birds should be easily accessible to operators to minimise rough handling. Image credits: Jo-Ann McArthur/WeAnimals.**

3.1 STUNNING METHODS AND EU LEGISLATION

The stunning of animals prior to slaughter is mandatory in the EU (albeit with a derogation for certain religious practices) and is based on the fact that animals, including poultry, are sentient beings that would experience pain, fear and distress when slaughtered while conscious. Stunning is performed to render the animals unconscious for a period that is long enough to guarantee that they do not recover during the bleeding phase. Stunning methods currently permitted in the European Regulation (EC) 1099/2009 include mechanical methods, electrical stunning and gas stunning methods. Recently, low atmospheric pressure stunning (LAPS) has also been authorised for poultry weighing less than 4kg. The two main stunning methods employed in commercial slaughter of poultry in the EU are electrical stunning in a multi-bird water bath and controlled atmosphere stunning (CAS) using CO_2. For both stunning methods, a form of handling and restraint of birds is necessary to bring birds from the transport container or crates into the stunner. Electrical stunning methods require the restraint of birds on a shackle line from which they hang upside down to facilitate proper application of the electrical current whereas controlled atmosphere stunning is performed with no form of restraint: birds are taken out of transport containers and pass through the stunning chamber on a conveyor belt. Alternatively, entire containers of birds, or drawers of containers pass through the stunning chamber.

The basic principle of the whole stunning process is that unnecessary suffering should be avoided, and this includes the unloading, handling and restraint of animals as well as the stunning method itself.

Figure 3.2 | **Shackles on a slaughter line. With electrical stunning, broiler chickens have to be individually inverted and suspended on the shackles while still conscious. This presents a series of animal welfare risks due to the speed of processing.**

3.2 HANDLING BEFORE STUNNING

The stunning process of poultry often requires for the birds to be taken out of the containers to be further handled to be hung on a shackle line or placed on a conveyor belt. Containers are moved from lairage, the waiting area, to the stunning area and emptied by hand or automatically depending on the type of container and stunning system. The most common types of containers are 1) plastic crates that can be opened at the top and or side to manually take out birds and that contain up to 12 broilers and 2) containers with 4 or 5 layers containing up to approximately 400 broiler chickens.

The type and design of crates and containers has an impact on the ease of manually removing birds from the containers. (Fig. 3.1) Small openings and sharp edges will increase the risk of animals being injured during handling. Similarly, when birds are difficult to reach, the catching of birds located away from the openings can be complicated, and the operator may tend to catch the animal roughly by the head, neck or wings, increasing the risk of injury (EFSA, 2019). Rough handling can cause pain and fear due to injuries. These would materialise as main carcass defects and can be seen as post-mortem lesions, such as skin lesions, wing fractures, and bruising on wings and breasts (Jacobs et al., 2017).

Containers with different layers or drawers can be emptied manually by removing the drawers from the rack manually or in an automated manner. The drawers are placed on a conveyor belt and birds can be either shackled for electrical stunning or the drawers can go with the birds into the CAS stunner. When containers are emptied automatically, a hydraulic platform operated by an employee tilts the entire container to dump the live birds onto a conveyor that runs into the shackle room (Tinker et al., 2005). One problem that can occur with dump modules is unloading the birds too fast. This results in birds falling on top of each other on the conveyor belts and pileups. When heavier birds are unloaded from the dump modules, the risk of broken wings is higher compared to lighter birds (AVMA, 2016). The negative aspects of dumping birds on a conveyor belt can be ameliorated by slowing down the operation.

Figure 3.3 | **When using CAS stunning, broiler chickens are presented to the stunning system on a conveyor belt in their transportation crates or containers. This eliminates the need to suspend them from the shackles while still conscious, before bleeding. Image copyright: Marel Group.**

In case of electrical stunning, birds are manually suspended (upside down) while conscious by their legs on shackles (metal hooks; Figure 3.2). According to Gentle and Tilston (2000), shackling of poultry involves the insertion of each leg into parallel metal slots by shacklers and holding the bird inverted for a period of time before stunning and slaughter; this causes pain and fear. Hanging the birds on to the shackles is performed by workers, at high speed, often resulting in a considerable number of bruised legs due to compression of the legs or broken bones (Veerkamp and de Vries, 1983; Sparrey and Kettlewell, 1994). The pain due to shackling is likely to be worse in birds with leg abnormalities (e.g. lame broilers) (Butterworth, 1999; Danbury et al., 2000).

To minimise the negative effects of suspending birds on the shackle line, it is important that personnel handle birds with care and avoid forceful suspension. Furthermore, the size of the shackles should be appropriate to the size of the birds and birds' legs. The moving shackle line may include sharp curves, inclinations, drops and bunchy transitions, causing irregular movements that can increase the force the shackles exert on the legs of the animals. The irregular movements and increased force on the legs can lead to painful compression and a fear response (EFSA, 2019) Design of the slaughter line with the shackles, i.e., length, corners, breast support systems can, to some extent contribute to limiting the negative effects of shackling.

In case of CAS stunning, birds are presented to the stunning system sitting on the conveyor belt or in their transportation crates or container (Figure 3.3). The birds are picked up and suspended on the shackle line after stunning and thus while unconscious, which will minimise or eliminate the negative effects of shackling (Uijttenboogaart, 1997). **CAS stunning systems in which birds enter the stunning system in their transportation crate or container prevent the hazards related to dumping the birds. This reduces the risks of pre-stunning stress or injuries.**

3.3 ELECTRICAL STUNNING

Electrical stunning in a multi-bird water bath stunner is the most used method globally for stunning poultry at slaughter. Eighty percent of chickens are stunned with this method in the EU[15]. The underlying principle is that birds hanging on the slaughter line pass an electrified water bath in which they receive an electrical current that runs through their bodies from head to legs. This current causes generalised epileptiform activity in the birds' brains, rendering them reversibly unconscious (Berg and Raj, 2015). At the commercial speed of the slaughter line, the number of birds that are in the water bath stunner varies widely but is somewhere between 4 to 32 animals at the same time. The effectiveness of water bath stunning is determined by the waveform (alternating current or pulsed direct current), frequency (Hz) and amount (mA) of current delivered to birds (Raj, 2006a). The current is the electrical parameter that induces the stun. However,

15 https://www.poultryworld.net/Health/Articles/2019/1/Diversity-not-uniformity-in-waterbath-stunning-378064E/

the effectiveness of the current or in other words, the minimum current to induce unconsciousness depends on the frequency of the current (Raj et al., 2006a and 2006b). The higher the frequency, the more current is required to induce unconsciousness (Hindle et al., 2010). The minimum currents delivered depending on different frequency ranges are stipulated in Council Regulation (EC) No. 1099/2009 on the protection of animals at the time of killing.

Electrical stunning using a multi-bird water bath system involves a number of different hazards to animal welfare, starting from being inverted and restrained on shackles, and pre-stun shocks at the entrances of the water bath.

Other hazards identified during this process are: 'poor electrical contact', 'too short exposure times', 'inappropriate electrical parameters' and 'inability to deliver minimum current to all the birds'. This second group of hazards can cause failure in onset of unconsciousness leading to pain and fear (EFSA, 2019). Furthermore, inadequate exposure can lead to early recovery of consciousness during the neck cutting procedure.

An important reason for increasing the frequency during electrical (water bath) stunning is to reduce quality problems like blood spots and lesions. Girasole et al. (2015) evaluated the impact of water bath stunning of broilers with different frequencies and current levels under slaughterhouse conditions and reported that all the experiments confirmed that high stunning frequencies lead to a lower occurrence of lesions on carcasses but require greater current intensities to be effective. Moreover, different studies (Kranen, 1999; Hindle et al., 2010; Girasole et al., 2015) showed that when the frequency is increased and at the same time the electrical current is increased to a level that successfully stuns all animals in the multi-bird water bath, (meat) quality problems will occur. In a recent study Girasole et al. (2016) investigated the effectiveness of stunning broilers with average RMS currents of 150, 200, and 250mA and frequencies of 200, 400, 600, 800, and 1,200Hz delivered using sine wave AC. The results indicated that, at a current level of 150 mA, the probability of a successful stun was over 90% at 200Hz, approximately 40% at 400Hz, and below 5% for frequencies greater than 600Hz. Based on the results, the authors concluded that the minimum current necessary to achieve effective stunning in 90% of birds is 150mA for 200Hz, 200mA for 400Hz and 250mA for 600Hz Stunning treatments at 1,200Hz provided the lowest probability of a successful stun even at the highest current level tested. The implication of these results is that frequencies above 600Hz would require RMS currents of more than 250mA, which are yet to be established. **The results of this study indicate that the required minimum settings according to Council Regulation (EC) 1099/2009 should be revised to ensure welfare.**

After stunning, it is legally required that birds are checked for unconsciousness by assessing indicators of consciousness/unconsciousness at key stages (EFSA AHAW Panel, 2013). Effective electrical stunning is characterised by the appearance of tonic/clonic seizures (showing as fast, uncontrolled muscle contractions), absence of breathing, absence of eye reflexes and spontaneous blinking (EFSA AHAW Panel, 2013). However, due to the high line speeds, up to 15,000 birds per hour in the EU, it is not possible to check all animals on the line. **Randomised checking of birds by taking them off the line would give a clear indication of the stun quality and should therefore be carried out systematically.**

3.4 CONTROLLED ATMOSPHERE STUNNING (CAS)

Gas stunning methods or Controlled Atmosphere Stunning (CAS) are often used to improve meat quality aspects and to avoid the pain associated with shackling conscious birds in the case of electrical stunning methods. Since CAS stunning doesn't induce immediate unconsciousness, the use of CAS is limited to birds in containers or on conveyors. Several commercially available CAS systems differ in the way birds are placed in the stunning system. Crates, containers or de-stacked drawers can be conveyed through a CAS system. In these processes, no handling of conscious birds is required. Shackling and handling are performed after the birds are stunned with a gas mixture (AVMA, 2016). According to EU Regulation 1099/2009 it is not permitted to expose birds to a high concentration of CO_2, >40%, while still conscious. This is because exposure of conscious birds to more than 40% CO_2 will cause painful stimulation of the nasal mucosa and aversive reactions (McKeegan et al., 2007). Therefore, gas stunning systems based on CO_2 are operated with a minimum of two phases; a first phase with a gas concentration below 40% CO_2 to

Figure 3.4 | **As CAS stunning does not induce instantaneous unconsciousness, monitoring animal welfare is important to avoid unnecessary suffering. Image copyright: Marel group.**

render the birds unconscious and a second phase above 40% CO_2 to secure deep levels of unconsciousness. The most common CAS stunning method is 2-phase controlled atmosphere stunning (CAS) or multi-step carbon dioxide stunning system (MCAS) but systems containing 30% CO_2 with 70% N_2 are also used in practice. Exposure to high CO_2 concentrations or to very low O_2 concentrations as with N_2 or Argon stunning systems induce serious uncontrolled muscle contractions (convulsions). These convulsions can lead to wing damage like bruises and broken or dislocated wings, which is a serious welfare concern, as well as leading to economic losses. Convulsive movements can be prevented by a gradual exposure to increasing CO_2 concentrations. In studies of multi-stepwise increases of CO_2 the appearance of convulsions were not observed or only at a very moderate level (Gerritzen et al., 2013). During exposure to the gas mixture, birds gradually lose consciousness. The speed of induction, depth and duration of unconsciousness induced with gas mixtures depends on both exposure time and gas concentration. Higher concentrations of CO_2 require shorter exposure times to induce a sufficient level of unconsciousness than lower CO_2 concentrations. **Exposure times and gas concentrations are therefore two crucial parameters to control during gas stunning.**

Since CAS stunning does not induce immediate unconsciousness, animal welfare aspects during the induction phase should be assessed. The exposure to gas mixtures will induce a series of behaviours that are typical and will have more or less impact on animal welfare. Interpretation of the effect, however, is not always easy, but monitoring the birds during this phase is important to avoid unnecessary suffering and to undertake appropriate interventions (e.g., on the gas concentrations or mixtures) if required (Figure 3.4.; see also text box).

At the end of controlled atmosphere stunning, birds should be checked at key stages for deep unconsciousness using appropriate indicators published by EFSA (2013) to ensure that animals will not recover before or during bleeding. In most cases, birds will be dead when exiting the CAS system. In any case, it is important to ensure that all birds are dead before processing them. Death can be confirmed from permanent absence of breathing, absence of corneal or palpebral reflex, dilated pupils and relaxed carcass (EFSA, 2013)

3.5 LAPS (LOW ATMOSPHERIC PRESSURE) STUNNING

A new development in CAS stunning is stunning poultry by exposure to a Low Atmospheric Pressure Stunning method (LAPS). In this method, broilers are placed in containers into the decompression chamber and exposed to gradual decompression with a reduction of available oxygen to less than 5% (Vizzier-Thaxton et al., 2010; Mackie and McKeegan, 2016; Martin et al., 2016a, b, c; Holloway and Pritchard, 2017). This method was found to be 'acceptable' based on the published scientific evidence for broiler chickens weighing up to 4 kg (EFSA, 2017). However, the EFSA (EFSA, 2019) recently identified several hazards during LAPS stunning, namely 'too fast decompression', 'expansion gases in the body cavity', and 'too short exposure time'. These hazards can cause persistence of consciousness, pain and respiratory distress (EFSA, 2019). As LAPS has not yet been adopted or tested in a commercial slaughter plant, an assessment of the animal welfare outcomes under commercial conditions is necessary.

INTERPRETING BIRD BEHAVIOUR DURING GAS STUNNING

During the induction phase, gasping (deep breathing with a stretched or arched neck) and head shaking will occur (McKeegan et al., 2006; Abeyesinghe et al., 2007; Gerritzen et al., 2007). Gasping is inherent to carbon dioxide stunning and is indicative of breathlessness whereas head shaking can be a reaction to different situations. Head shaking is perceived as an alarming or alerting response, but it also is associated with a reaction to unpleasant, irritating or painful inhalation of gas. After some time, the birds will lose balance, frequently being corrected by wing flapping or jumping up; this should not be interpreted as escape attempts because they are corrective measures by the birds to maintain their balance or posture. Loss of posture, and thus an inability to maintain body position, indicates the moment of loss of consciousness (Gerritzen et al., 2004). After loss of posture, when animals are unconscious, gasping will continue for some period of time and convulsions (uncontrolled muscular movements) can occur. The interpretation of visual animal-based measures (ABMs) during the exposure to gas mixtures depends strongly on the moment that behavioural expressions start. For example, continuous wing flapping that starts directly after exposure can indicate escape attempts and is seen as an aversive reaction to high CO_2, whereas short wing flapping to regain or maintain posture does not necessarily indicate an aversive response to high CO_2. In addition, for head shaking, the interpretation depends on the intensity and level of head shaking. Severe or vigorous head shaking can be interpreted as a sign of painful or irritating inhalation of gas mixtures.

CONCLUSIONS

The process of poultry slaughter includes the pre-slaughter handling and restraint of birds that is necessary to present birds to the stunning system. Unloading the birds from the containers by hand or by dumping is the first hazard that occurs in this part of the process. Different CAS stunning systems that do not require birds to be unloaded before stunning will therefore reduce the animal welfare risks in this part of the stunning process. Restraining, or more specifically, shackling of conscious birds before electrical stunning has a major impact on animal welfare. Shackling can be painful due to the compression of the legs and will lead to fear on account of hanging upside down in an unnatural position. **Applying stunning methods that do not require restraining or inversion is preferable from an animal welfare perspective.**

CAS stunning reduces the pre-stunning risks associated with unloading, dumping and shackling and from that perspective CAS stunning is preferable over electrical stunning. However, the induction of unconsciousness in a CAS stunning system is not immediate and will be stressful to the birds. In particular, a period of breathlessness will occur before the animals lose consciousness. In principle, birds in multi-bird electrical water bath stunning systems should be rendered unconscious instantly. However, **commercial settings of multi-bird water bath stunners and the large difference between individual animals will in many cases lead to a substantial percentage of birds that will not lose consciousness immediately or will not be stunned at all.** This is incompatible with basic animal welfare requirements at the time of slaughter and warrants, as a first step, a revision of the required minimum settings for water bath stunning set down in Regulation 1099/2009 and stricter oversight mechanisms. In the longer term, a phase out of this method in favour of more humane alternatives is to be recommended.

Based on an assessment of the welfare implication of stunning chickens with different methods, it can be concluded that CAS stunning is currently to be preferred above multi-bird water bath stunning.

Stunning birds in the transport modules will reduce the welfare consequences related to pre-stunning handling and should therefore be encouraged.

SECTION 2

This section deals with two aspects that are not specifically covered by EU legislation (if we exclude the General Farm Animals Directive), namely the keeping and protection of parent birds and the protection of hatchlings (newly born chicks) in commercial hatcheries. In Europe it is estimated that between 50 and 60 million parent birds produce the 8 billion broiler chickens that are consumed each year. These fast-growing birds are produced by two large companies that together dominate the market. Broiler parent birds (breeding animals) live longer and have a distinct set of animal welfare challenges compared to broiler (i.e., meat) chickens. The fertilized eggs are then normally incubated in commercial hatcheries, where hatchlings are exposed to a series of welfare challenges, including noise, darkness, noxious chemicals, absence of food and water, handling and transport. The specific challenges encountered by parent birds and hatchlings have the potential to impair compromise their health and welfare, and therefore they would benefit from specific EU rules.

4.

WELFARE OF BROILER PARENT BIRDS

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Broiler parent birds ('broiler breeders') are the parent birds who produce the eggs from which broiler chickens (meat chickens) hatch. Broiler chickens are reared for about 6 weeks before they are killed for consumption as whole chicken or for parts (as ingredients) in food dishes. The welfare risks for broiler chickens are described in Chapters 2 and 3 of this report. Less studied are the life stages of, and welfare risks for, broiler breeder birds and this chapter presents information on how these birds are reared and what the risks to their welfare are.

Key messages

- There has been very little animal welfare research on broiler parent birds in comparison with research on broiler chickens or laying hens.
- Just two major international companies supply nearly all of the world's commercial parent birds.
- Parent birds have been selected to have very strong appetites and a high growth potential. These traits result in offspring (broiler chickens) that grow rapidly to slaughter weight.
- Unlike their offspring, parent birds live for many months and their growth is controlled by severe feed restriction. This also serves to maintain their reproductive function.
- Severe feed restriction results in elevated levels of physiological stress, altered brain development, increased activity and aggression, performance of abnormal behaviour, reduced resting time and chronically high, but unsatisfied feeding motivation.
- Attempts to resolve this problem include adding fibre to the diet to increase a sensation of gut-fill, or by altering schedules of feeding. Neither approach is fully effective in resolving the problems of severe feed restriction.
- The use of slower-growing genotypes may ultimately be a more complete and ethical solution to the welfare problems faced by broiler breeder birds.
- The welfare of broiler parent birds would be improved by increased attention to effective environmental enrichment to improve health and satisfy behavioural needs.
- Further work is needed to assess the prevalence of aggression in broiler parent bird flocks and to design housing and management systems that reduce male aggression towards female birds. This would also reduce the perceived need for harmful interventions such as beak trimming and toe clipping.

4.1
GENETICS, MANAGEMENT AND HOUSING

Parent birds origin

The broiler breeding industry has a pyramidal structure (Figure 4.1) with pedigree (pure line) birds kept in isolated or remote locations, with extremely strict biosecurity arrangements. The progeny of the pure line birds constitutes the great-grandparent and grandparent generations, which in turn produce parent bird hybrids (broiler breeders). Figure 4.1 shows that the male and female parent birds are different breeds. In Europe it is estimated that between 50 and 60 million parent birds produce the 8 billion broiler chickens that are consumed each year.

Similarly to the laying hen industry, the broiler breeding industry is highly consolidated. Just two major companies, Aviagen and Cobb-Vantress dominate the global market for fast-growing commercial genotypes, producing Ross and Cobb birds respectively. In February 2018, a third company, Hubbard, became part of the Aviagen Group, although it currently retains a separate breeding programme. Cobb-Vantress is owned by the Tyson group.

This market dominance by only two companies has implications for the overall genetic diversity of parent birds and their offspring and raises complex ethical questions similar to those arising from global dominance in the laying hen sector (Fernyhough et al., 2019). Limited genetic diversity can, for example, threaten bird health (Fernyhough et al., 2019) and it clearly reduces market competition, thereby affecting consumer choice. In addition, a combination of high bird value, commercial sensitivity and stringent biosecurity means that non-company independent researchers can rarely (if ever) access pedigree, great-grandparent and grandparent birds. Access to parent birds is more achievable but it should be recognised that, in comparison with animal welfare studies of broilers or laying hens, there is relatively little independently generated data about broiler parent birds.

Organic or other small-scale production systems (e.g. Label Rouge) tend to utilise alternative breeds with slower growth rates, but historically this has reflected niche production involving only a very small fraction of European birds. This picture is changing rapidly as assurance schemes with a focus on animal welfare, such as RSPCA Assured (UK) and Beter Leven (Netherlands), advocate the use of slower-growing broiler breeds. These initiatives are driving an increased demand for slower-growing breeds within the conventional broiler sector.

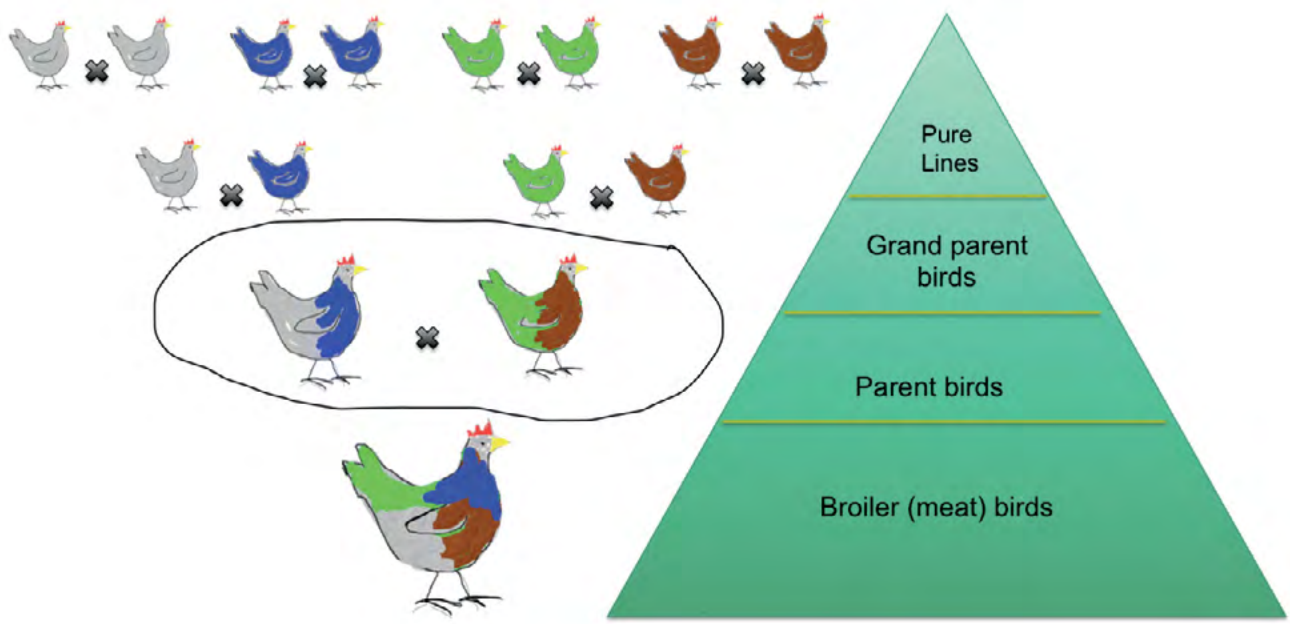


Figure 4.1 | **Hybrid parent birds (ringed) produce the many meat birds consumed in Europe each year. Image copyright: Christine Nicol.**

Management

Rearing phase

The management of parent birds comprises an initial rearing phase during which birds are kept in single-sex groups, generally in litter-based barn systems. Cage rearing is uncommon in Europe (de Jong and van Emous, 2017). From about 6 weeks of age, elevated platforms or perches are provided to allow birds to develop locomotor skills and confidence to use elevated tiers during the subsequent production period. During this period, the young male and female birds are provided with differing diets to support differing growth targets. Management is focussed on producing birds that meet these growth targets with good bird condition, and a high level of flock uniformity. For this reason, culling (i.e., selective elimination/killing) levels may be relatively high, although exact figures are not known. In addition, some birds are culled during the rearing phase because they have been incorrectly sexed. Feed is distributed in pans, or by chain or spin feeders that spread the feed over the litter. The rearing phase persists until birds reach sexual maturity at 18-22 weeks, at which point they are transferred to the production house and male and female birds are mixed.

Production phase

During the production phase, the parent birds produce fertile eggs for commercial broiler farms and will continue to do so until they are depopulated (i.e., sent to slaughter) at approximately 60-65 weeks of age. At this stage, birds are again predominantly kept in litter-based systems with elevated tier areas incorporating nest boxes and sometimes other resources, such as water on the tiers. A small proportion of flocks may be housed in colony (gr oup) cages (de Jong and van Emous, 2017). Differential feeding is maintained by using separate feeding systems. Males are provided with feeder pans at a height that the smaller hens cannot access, while females feed by placing their heads through grilles that are too narrow for the male birds to use. The sex ratio during the production phase starts at approximately 1 male for every 9 females, but this changes over time due to high culling levels for male birds. The proportion of male birds that are culled for poor performance such as a lack of active mating behaviour is estimated at 15-20%.

ANIMAL WELFARE

The factors that influence animal welfare are multi-dimensional, as reflected by the Five Freedoms concept (Webster, 1994). Versions of the Five Freedoms now form part of most official definitions of animal welfare e.g. World Organization for Animal Health (OIE, 2019) and have provided a ubiquitous guide for welfare assessment for the past 30 years. However, a revised and reconfigured version of this framework, termed the Five Domains Model (FDM) of animal welfare (Mellor and Reid, 1994) has potential advantages in facilitating a systematic, structured and coherent approach. The FDM focuses attention on four domains ('nutrition', 'environment', 'health', 'behaviour') which are likely to give rise to the fifth 'mental state' domain which reflects the integration and organisations of these other inputs into affective (emotional) states. Animal welfare scientists are able to measure the valence (positive or negative) and intensity of affective states such as pain, hunger or excitement. These affective states may additionally be accompanied by subjective feelings, but these cannot be directly studied. Both the Five Freedoms and the FDM frameworks show that welfare must be assessed using a range of measures. Single measure studies (e.g. of plumage damage or leg health) provide important information but must be integrated with other available information to draw conclusions about overall welfare at a given point in time. Taking a longer view, the welfare state of a chicken is not constant and it will vary over time. It is therefore important to consider the sum total of an animal's experiences. If, across a lifetime, negative experiences predominate and are not alleviated or outweighed by compensatory positives, then the animal's life could be described as "not worth living" (FAWC, 2009). The aim of most animal welfare scientists and advocates is to ensure that animals lead lives that are at least worth living, and that preferably are "good lives", where positive experiences clearly outweigh any transient or relatively minor negative experiences.

This review will focus on specific challenges affecting broiler parent birds, and the measures that have been used to assess their impact. These challenges include the high growth potential of parent birds and the resultant practice of feed restriction; the extent to which current housing meets behavioural needs; concerns relating to physical health, including overall mortality levels and bone, leg, foot and skin condition; harmful or aggressive social interactions; and the routine use of interventions or management practices that may cause harm. Integrating this information provides a picture of the overall welfare of parent birds in Europe.

4.2
NOTABLE WELFARE CONCERNS

Growth potential and feed restriction

Parent birds produce fast-growing offspring (meat chickens) with high appetite and breast muscle yields. This has not been achieved without cost. The parent birds themselves also have high growth potential, and their modulated mechanisms of hunger regulation results in a similarly high appetite as their offspring (Siegel and Wolford, 2003). However, whereas the commercial broilers grow rapidly and are slaughtered at just a few weeks of age, the parent birds must retain a degree of physical health and reproductive capacity. If they are allowed *ad libitum* (i.e., free) access to food they gain excess weight, deposit fat and experience a range of serious health problems including lameness, ascites[16] and premature death. Their reproductive capacity is also compromised due to altered ovarian function that results in poor fertility and multiple ovulation (Hocking et al., 2002a; Heck et al., 2004; Renema and Robinson, 2004). This has been described as the broiler breeder paradox (Decuypere et al., 2010).

To avoid these fertility and reproductive problems, parent birds are given severely restricted quantities of feed during both the rearing and production phases. Male birds are given unrestricted feed for the first few weeks of life and are then subject to a degree of feed restriction, but to a far lesser extent than females. Female birds have unrestricted access to feed only during their first week of life. After this, their intake is restricted to just 25-33% of the amount they would voluntarily consume (de Jong and Guémené, 2011), with the most severe restriction occurring after 10 weeks of age. Due to continued selection for rapid growth of broiler chicks produced by parent birds by the breeding companies (Zuidhof et al., 2014) it is very likely that the relative feed restriction is increasing yet further. Further information regarding this point is required for any comprehensive welfare assessment.

Feed restriction continues during the production phase, but to a slightly reduced extent for female birds. The feed allocation for female birds at this time is said to vary between 45 to 80% of ad libitum intake, depending on their age (Bruggeman et al., 1999). During the production phase, the male birds may be more restricted than the females. It is not easy to obtain information on current commercial practice or on the extent of nutrient restriction. As growth potential targets constantly shift, it is likely that parent birds will be subject to increasingly severe levels of feed restriction. Feed is generally provided in one small meal per day and daily feeding is required in some European countries including Sweden, Denmark, the UK and Norway. In other countries, parent birds may be fed only every other day ('skip-a-day' feeding). Intermediate programmes can be used meaning that birds are fed for only 4, 5 or 6 days out of every 7 but that they are provided with a larger meal on the feeding days.

Although feed restriction can stave off some physical health problems associated with overeating, it results in many additional welfare problems for the birds (D'Eath et al., 2009). These are considered next.

Consequences of restricted feeding: HEALTH.

Feed restriction of female birds during the mid-rearing period delays the onset of sexual maturity but leads to improved fertility during the production phase (Hocking et al., 2002a). There are beneficial effects of restricted feeding on health, as females allowed unrestricted access to feed gain excess weight which is deposited around the abdomen and visceral organs.

However, there are also detrimental effects of restricted feeding on bird health. One example is that the development of new nervous system tissue is suppressed by the chronic stress associated with feed restriction. This phenomenon has been well studied

[16] A disease linked to inadequate supplies of oxygen, poor ventilation and physiology (strain), leading to pulmonary arterial vasoconstriction.

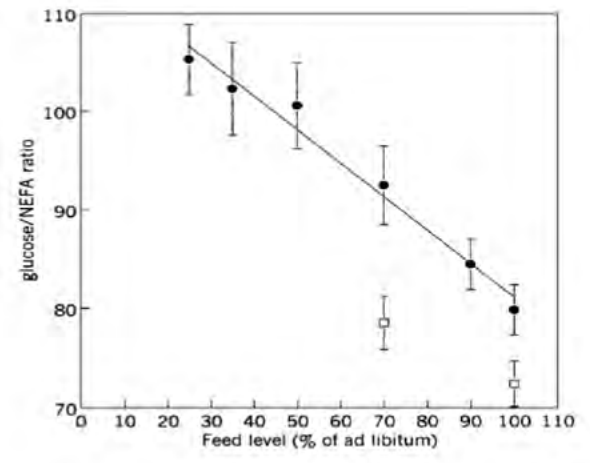
in mammalian species but less so in birds. Robertson et al. (2017) discovered that broiler breeders fed at commercial levels of feed restriction during the rearing period showed elevated levels of stress hormones and had a significantly reduced density of new neurons in the hippocampal region of the brain (which is important for learning, emotion and memory) when compared with *ad libitum* fed birds. This work is at a very early stage and the full implications of feed restriction on brain development and cognitive ability need to be clarified further.

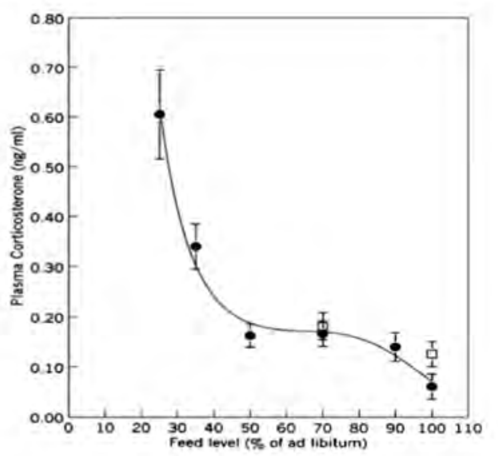
Consequences of restricted feeding: FEAR AND STRESS

Birds that are subjected to feed restriction (primarily the severe feed restriction imposed on female birds during rearing) usually show elevated baseline levels of stress hormones (plasma corticosterone) (Hocking et al., 1996; Savory and Mann, 1997; Hocking et al., 2001; Kubikova et al., 2001; de Jong et al., 2003; Robertson et al., 2017) and are also more sensitive and stress responsive to other challenges (de Jong and Guémené, 2011). Research shows that the elevated stress hormone levels seen in broiler breeder females are relevant in the assessment of their welfare. The current scientific hypothesis that modern strains of broiler breeder have higher baseline stress levels is important and requires further investigation (see box).

IS CORTICOSTERONE A GOOD MEASURE OF BIRD WELFARE?

There has been some debate as to whether corticosterone is a good measure of bird welfare in this context, because it could be affected by changes in metabolism associated with the level of feed received, it may be affected directly by bird weight and it is not necessarily a good measure of a chronic condition such as hunger, because birds may show adaptive responses (D'Eath et al., 2009). de Jong et al. (2003) took independent measures of bird metabolism including the glucose/fatty acid (NEFA) ratio and found that this was linearly affected by level of feed restriction (Figure 4.2). In contrast, the levels of corticosterone showed non-linear relationships with feed restriction (Figure 4.2b), with the most severe level of feed restriction resulting in a 3-fold increase in corticosterone. Others have also found non-linear effects of feed restriction (Hocking et al., 1996). Kubikova et al. (2001) also reported a 3-fold increase in the most severely restricted female birds tested at 13 weeks of age. This strongly suggests that corticosterone is not simply a marker of metabolism but that it may reflect some element of psychological stress or frustration.





Figures 4.2a (left) and 4.2.b (right) | **The first figure (A) shows how nutrient levels in the blood are affected by feed restriction. Glucose levels do not change greatly, but fatty acid levels decrease in a linear manner so that the ratio between fatty acids and glucose is very high at the most extreme levels of feed restriction. This can be seen on the left-hand side of (A). In contrast, figure (B) shows little evidence of an elevated stress response (measured by plasma corticosterone) when feed is restricted to 50% of free intake. However, stress levels increase dramatically when birds are restricted to 40% of less of their free intake. Importantly, this major increase in stress cannot simply be explained by physiology and it likely indicates a strong element of psychological stress. Reproduced with permission from: de Jong et al. (2003).**

In contrast to these results, van Emous et al. (2014) studied the effects of feed restriction on Ross 308 female birds reared to 20 weeks to different target weights. The more severely restricted birds achieved a 20-week bodyweight of 2200g, while less restricted birds, fed 6.5% more feed, had an average body weight of 2400g. In this experiment no differences in plasma corticosterone concentration were detected. Importantly, however, these authors propose that stress hormone levels in broiler breeder birds are now generally extremely high, potentially masking small treatment differences. They noted plasma corticosterone levels during rearing (approximately 1.8 to 3.5 ng/ml) that were 5 times higher than in studies conducted 10-15 years previously (e.g. de Jong et al., 2002; 2003).

Consequences of restricted feeding: ACTIVITY, ABNORMAL BEHAVIOUR AND AGGRESSION

Activity levels are high in feed-restricted birds, with much time spent in locomotor, foraging and pecking activities (Hocking et al., 1993; Zuidhof et al., 1995; Hocking et al., 1996; Savory and Lariviere, 2000; Savory and Kostal, 2006). **Activity levels increase with the severity of feed restriction** (Jones et al., 2004) and this is most often interpreted as a sign that birds are continuing to search for possible food sources. **These high levels of activity permit little time for other beneficial activities such as resting, preening or performing other comfort behaviours** (de Jong et al., 2003; Puterflam et al., 2006; Nielsen et al., 2011). Providing birds with multiple small meals throughout the day via randomly-timed precision feeding techniques provides birds with more opportunity to focus their foraging behaviour, and in one study resulted in a 53% increase in resting behaviour which occurred in the intervals between foraging bouts (Girard et al., 2017a).

Another consequence of severe feed restriction is **the development of 'spot' pecking, directed at specific regions of the house, and particularly at stimuli around empty feeders, walls, drinkers and other items of pen furniture.** As with activity, the amount and intensity of this behaviour is positively correlated with the degree of feed restriction (Savory and Lariviere, 2000; Merlet et al., 2005; Sandilands et al., 2005) and hence occurs in its most intense form in female birds during the rearing period (Hocking et al., 2002b). **The repetitive and invariant nature of spot pecking suggests that it could be classified as a stereotypic behaviour.** The fact that it occurs primarily after feeding (de Jong et al., 2002; Hocking et al., 2002b) suggests strongly that it is initially triggered by an unfulfilled and frustrated motivation to continue feeding but, as with other forms of stereotypic behaviour, it may become dissociated or emancipated from its original causes (Mason et al., 2007).

Repetitive pecking by feed-restricted parent birds may also be directed towards other birds. As with spot pecking, feather pecking tends to occur most often during or after short bouts of feeding and thus is similarly indicative of ongoing frustrated hunger (Morrissey et al., 2014a; Girard et al., 2017a). Female parent birds raised on a commercial level of feed restriction were found in one study to show excessive pecking at other birds' tails, and also a degree of self-directed tail pecking (Nielsen et al., 2011). Self-directed pecking is very rarely reported in other forms of poultry production, although it is relatively common in various species of captive parrots, where it arises in birds with a low resilience to environmental stressors (Cussen and Mench, 2015).

Drinker-related pecking and activity is another behaviour commonly observed in feed-restricted broiler breeders and, as with the behavioural indicators mentioned above it increases with degree of restriction (Jones et al., 2004). In standard genotype parent bird females fed on commercial levels of feed restriction, drinker-related activity can occupy more than 30% of the birds' time budget during the period of most intense restriction between 10 and 15 weeks of age (Jones et al., 2004). In some studies, increased time spent at the drinkers is also associated with over-drinking, which may be an attempt by hungry birds to increase gut-fill (Hocking et al., 1993; 1996).

MEASURING HUNGER AND FEEDING MOTIVATION IN BROILER CHICKENS

The studies reviewed above have measured behavioural and physiological indicators associated with feed restriction. High levels of activity, non-functional pecking and over-drinking, low levels of rest and indications from many studies of an increase in physiological stress, strongly suggest that birds on restricted diets may experience hunger. However, hunger is a motivational state and may be better measured using carefully controlled experimental protocols.

COMPENSATING FOR PREVIOUS LACK OF FOOD

One approach to a more direct assessment of bird hunger is to examine how much feed (controlled for bodyweight) a bird will consume when it is given the opportunity. de Jong et al. (2003) found that young females provided with commercial levels of feed restriction showed a compensatory feed intake that was far higher than for birds fed ad libitum – approximately 65g vs 40g per kg metabolic weight – in the first few days of free food availability. Even after 3 weeks, feed intake of the most severely restricted birds exceeded that of the *ad libitum* controls, suggesting a substantial food deficit that cannot be rapidly overcome. Nielsen et al. (2011) examined hunger motivation in a similar way, looking at compensatory feed intake, while additionally recording feeding rate (in a manner that overcame some methodological problems encountered by Sandilands et al., 2005). Nielsen et al (2011) also included a novel food test designed to measure the conflict between fear and hunger level when novel food was presented in a novel container. Birds fed on commercial low fibre diets were tested against birds supplied with twice the amount of fibre, presented in different formulations (see the section on solutions for chronic hunger below). All treatment groups were re-tested after they had received *ad libitum* food for 5 days. Birds given the low fibre diet were more likely to approach and feed from the novel feeder in comparison with one of the high fibre diets. These low fibre birds also ate at a faster rate and showed a higher compensatory feed intake. Taken together, these results strongly suggest that hunger drives risk-taking behaviour, an interpretation strengthened by the fact that the *ad libitum* fed birds did not use the novel trough at all.

WORKING TO REACH FOOD

An alternative way of examining how feed restriction affects motivation was pursued by Dixon et al. (2014). These researchers found that female broiler breeders, aged 7 to 11 weeks during the testing period and kept at commercial levels of feed restriction, worked harder for the opportunity to forage than control birds given 2 or 3 times more feed. Motivation to forage was assessed by observing how many times each bird would traverse a water-filled runway to reach a shavings-filled exploratory area. As trials progressed, the runway became increasingly longer, to a maximum of 4m, and deeper, to a maximum of 112mm. The most restricted birds were willing to trade-off their aversion to the water crossing against the reward of expressing foraging behaviour. It is interesting that the feed restriction affects foraging motivation even in the complete absence of any actual feed reward. As Dixon et al. (2014) argue, the results provide good evidence that **feed-restricted birds feel continuously hungry during periods when no food is available.** The results contradict the alternative hypothesis that female broiler breeders are unaware of their own hunger until food is directly presented.

Most studies of parent bird feeding motivation have been conducted with female birds during the rearing period when levels of feed restriction are at their highest. However, it is important to remember that feed restriction at a lesser level persists through the production phase. **Broiler breeders continue to show evidence of a high motivation to eat, and will forego other important behaviours such as nesting, to obtain food** (Sheppard and Duncan, 2011).

Solutions for chronic hunger

Feed dilution and appetite suppression

Some of the adverse consequences of food restriction can be avoided by increasing oral satisfaction or the sensation of gut-fill by **bulking diets with fibre or other non-nutritive substances, thus reducing overall nutrient density.** This is referred to as **qualitative feed restriction** and it allows broiler breeders to consume a greater volume of feed and reliably increases the time that birds spend feeding in comparison with birds fed smaller quantities of nutrient-dense diets. In some studies, qualitative feed restriction has been associated with reduced indicators of frustration and hunger (Hocking et al., 2001; 2004; de Jong et al., 2005; Nielsen et al., 2011; Moradi et al., 2013; Van Emous et al., 2014; 2015a; 2015b). In particular, the inclusion of a higher level of insoluble fibre has positive effects in reducing abnormal behaviour and activity, promoting more resting and comfort behaviour, and reducing indices of fear and stress (Hocking et al., 2001; 2004; de Jong et al., 2005; Sandilands et al., 2006; Nielsen et al., 2011) as well as reducing signs of over-drinking (Savory et al., 1996). de Jong et al. (2005) found that reduced abnormal behaviour was observed during the first part of the rearing period but not during later rearing or during the production phase.

Including soluble fibre (such as sugar beet or potato pulp) in diets appears more problematic, although it has the potential to further increase gut-fill by increasing water absorption. Although Hocking et al. (2004) found that abnormal pecking behaviour was reduced, Nielsen et al. (2011) observed signs of intestinal discomfort in birds on such diets and also problems with wet droppings adversely affecting litter quality. Even when insoluble fibre is used to bulk diets it does not always have an observable effect in reducing abnormal behaviour (e.g. Savory and Lariviere, 2000) or stress (Jones et al., 2004; Hocking, 2006; Sandilands et al., 2006). In addition, despite improved gut-fill and evidence of reduced hunger (Nielsen et al., 2011) birds provided with high fibre or diluted diets are still metabolically hungry (i.e., they lack nutrients) and maintain a high motivation to feed when compared with *ad libitum*-fed birds (Savory and Lariviere, 2000).

Another approach to interfere directly with bird hunger has been the use of an appetite suppressant (calcium propionate, CaP). The inclusion of 5-9% CaP reliably lowers feed intake in broiler breeders (Sandilands et al., 2005). It also controls growth rate and results in lower levels of physiological stress (Arrazola et al., 2019), as well as reduced expression of abnormal behaviour and reduced signs of feeding motivation in some experiments (Sandilands et al., 2005; 2006; Tolkamp et al., 2005; Morrissey et al., 2014b; Arrazola et al., 2019) although not all (Savory and Lariviere, 2000). The problem with CaP is that it increases aversion to feed (either its taste or its intestinal consequences) rather than simply producing a feeling of satiety (Arrazola and Torrey, 2019) and its use is associated with oral and digestive tract lesions in poultry (Tolkamp et al., 2005). Therefore, adding CaP to parent bird diets can be considered as detrimental to animal welfare.

In summary, it appears that qualitative methods of feed restriction can, to a limited degree, improve the welfare of broiler breeders in comparison with commercial practices. However, there is no good evidence that any of the methods to reduce hunger in broiler breeders tested so far is fully effective, and that some of the methods even have adverse effects on animal health and welfare.

Non-daily feed regimes

Birds on a variety of skip-a-day regimes have improved plumage condition (Morrissey et al., 2014a; Arrazola et al., 2019) and reduced object pecking, aggression (Morrissey et al., 2014b) and feeding motivation (Arrazola et al., 2019) compared with birds fed an equivalent amount in smaller daily feeds. However, birds on the skip-a-day regime may perform more feather pecking during the feeding bouts (Morrissey et al., 2014b). In addition, Lindholm et al. (2018) found signs of increased physiological stress as well as increased fat deposition and reduced muscle growth. However, they showed lower levels of activity prior to feeding which was interpreted as an indicator of lower anxiety at this time. The above studies compared skip-a-day feeding regimes against conventional daily feeding. When skip-a-day feeding was compared with precision feeding that provided birds with many small meals per day, the skip-a-day birds were more active in walking, foraging and feather pecking, whilst the precision-fed birds performed more sitting, drinker-pecking and aggression (Girard et al., 2017a,b). The benefits of altering feed timings without increasing nutrient or overall feed intake thus appear mixed. It is worth noting the opinion of Savory and Lariviere (2000) who found few positive effects of any alternative methods of feed restriction and concluded that if feed restriction was sufficient to cause growth restriction, the method of restriction was immaterial. Feed-restricted birds were always hungry.

Different genotypes

The use of different genotypes may ultimately be a more complete and ethical solution to the welfare problems faced by broiler breeder birds. **The use of genotypes that can be kept without feed restriction is a critical goal in animal welfare science.** This can be achieved by using slow-growing genotypes (such as those now produced by Aviagen under their Rowan Range label, such as the Ranger Classic and Ranger Gold; the Hubbard JA757, JA787 and JA987), which usually produce slow-growing progeny. At the moment slower-growing broiler chickens are only used to a limited extent across the EU and worldwide, although their market potential is increasing (see Chapter 6). Slow-growing females crossed with standard male breeders also produce offspring with only slightly slower growth periods (Puterflam et al., 2006). Another approach has been to use lines where female birds have a reduced growth potential due to selection for reproductive traits and dwarfism. This does not affect their fertility and the need for feed restriction is greatly reduced (Decuypere et al., 2010). The level of abnormal behaviour associated with this lower level of restriction is greatly reduced (Jones et al., 2004) and the experimental dwarf birds spent more time resting. The experimental dwarf birds spend more time resting throughout the rear and during the early production phase and their egg production is greater than that of standard genotypes (Puterflam et al., 2006). The offspring of such dwarf females reach production weight targets just a few days later than conventional genotypes. The dwarf gene affects only the female birds, so (as with the slow-grower cross) the male birds still have to be feed restricted. But the restriction levels of male birds, as well as the numbers affected, are far less than for the current high number of severely restricted females.

Water restriction

Feed-restricted parent birds may increase their intake of water (Hocking et al., 1993). This can increase litter moisture and susceptibility to footpad dermatitis (Li et al., 2018). As a consequence, **producers may restrict water access in parent bird flocks.** The extent to which this occurs commercially is difficult to ascertain and practice may vary between countries (EFSA, 2010). The Ross parent bird management guide (Aviagen, 2018) suggests that birds should have unlimited access to a clean, fresh water supply at all times (p 35) but states later (p 151) later on that this applies "when birds are

active". Further notes (Aviagen, 2015) suggest that controlling water provision after 6 weeks of age during periods when water intake is naturally low (such as during the night) might help to reduce water leakage which will lead to wet litter. The Cobb-Vantress guide (Cobb-Vantress, 2018) (p 17) states only that it is essential to provide easy access to fresh, clean water so that feed intake and growth are maintained.

The Hubbard management manual (Hubbard, 2015) advises some degree of control of water supply, stating that water should be given about 30 minutes before feed is distributed and must remain available 1 to 2 hours after the feed has been finished. It also advises that water is provided 30-45 minutes before the dark period, but this does suggest that birds will spend most of their time without either feed or water.

The potential effects of water restriction on bird health have received very limited research. Hocking et al. (1993) did not find that water restriction resulted in altered markers of physiological stress, but the degree of water restriction may not reflect current practice and more work is needed here.

Housing and additional behavioural needs

Roosting, perching, nesting and dustbathing – need for enrichment

Chickens perform certain behaviours even in the absence of an appropriate resource (e.g. by dustbathing on a slatted or wire floor in the absence of a loose substrate) and even if a resource that already fully meets the ultimate function is available (e.g., nesting behaviour can be performed even in the presence of a perfectly formed nest). **For good welfare, birds should be able to perform these behaviours and not be further restricted by spatial or other physical constraints from being able to do so** (Weeks and Nicol, 2006). Further, some behaviours can be described as priorities because experimental studies demonstrate that birds will expend time and energy (work), forego other opportunities, or withstand aversive conditions in order to secure the opportunity to perform these most important behaviours (Weeks and Nicol, 2006). For instance, in laying hens, foraging, nesting and roosting in an elevated position at night are high priority behavioural needs regardless of the environment within which the birds are housed (Weeks and Nicol, 2006; EFSA, 2015). In contrast, the motivation to dustbathe appears to be influenced to a greater extent by environmental factors. There is considerably less research on the behavioural needs and priorities of broiler breeders than for laying hens, with just a handful of peer-reviewed papers and conference abstracts available (Riber et al., 2017). Given the paucity of data, a degree of generalisation from layer strains in terms of bird motivation should be permitted until further information is available, taking into account in any case that there are marked physical differences between broiler breeders and laying hens.

The provision of a loose litter substrate on the floor is important in reducing levels of stereotypies and feather pecking compared with birds housed on bare slats (Hocking et al., 2005). However, the benefits of providing further non-edible foraging enrichments, such as bunches of string are less clear (Hocking and Jones, 2006).

The provision of suitable nests is an essential aspect of broiler breeder management. Most eggs are laid in the nests provided, although floor eggs do occur and possibly at a higher rate than for laying hens. Holcman et al. (2007) reported that 5.1% of eggs were not laid in nests, partly due to subordinate hens being excluded by competition from favoured nest boxes. This suggests the importance of adapting nesting provision to improve female parent bird welfare and also to improve hatchability and survival of chicks, which is lower from eggs that have been laid on the floor (van den Brand et al., 2016).

Some important studies have emerged from Switzerland on the effects of providing perching facilities for broiler breeder birds. In Switzerland (but not in the EU as a standard provision) all breeding birds must have access to perches. Gebhardt-Henrich and Oester (2014) found that **broiler breeders preferred to use elevated structures such as raised slats or platforms** more than perches provided at a lower height. Welfare concerns are therefore that elevated structures

ELEVATED PERCHES AND PLATFORMS AS ENRICHMENT

The usage of elevated structures was sustained for longer in a slower-growing JA strain than in a fast-growing Ross genotype, where usage declined markedly during the production phase (Gebhardt-Henrich and Oester, 2014). Gebhardt-Henrich et al. (2017) housed Ross 308 birds in pens with perch spaces of 0, 5, 10, 14 or 20cm per bird. Night-time perching was facilitated by a perch length of 14cm per bird or more, mortality was reduced with perches and production was not adversely affected by perch provision. These encouraging results were followed by a trial where broiler breeders of the Ross and (slower-growing) Sasso genotypes in control pens, perch-pens containing A-frame perches, or aviary tiered pens. Birds from both genotypes used the elevated structures for resting during the day, but predominantly for roosting at night. Night-time roosting reached a maximum at around 20 weeks of age, and declined thereafter, with a slower decline in structure use in aviaries than with A-frame perches. Birds from the Sasso genotype showed greater use of elevated structures, had improved plumage condition but also experienced a higher level of keel bone fractures, although this was not directly influenced by exposure to elevated structures. This work demonstrates that broiler breeder birds are likely to value the provision of elevated structures during both rearing and production phases.

Figure 4.3 | **The high mortality during different phases of the broiler breeders' life cycle is an animal welfare concern. Image copyright: Jo-Anne McArthur.**

are not routinely provided during the ***rearing period,*** despite the known benefits of provision at this age in layer strains, such as increased mobility (e.g. Norman et al., 2018), protection from bone fractures, and reductions in fear and aggression. Despite encouraging early results suggesting that elevated structures do not increase the broiler breeder's risk of bone damage and fractures (see Science Box) further work in this area will be important. Keel bone fractures do occur in broiler breeders (albeit at a lower level than in laying hens) and the role of the housing environment is not yet clear.

Dustbathing in broiler breeders has been little studied. It occurs more in birds that are provided with higher-fibre diets (Nielsen et al., 2011). It will not be possible for female birds to perform full dustbathing behaviour if they are fearful of moving to the litter area or likely to be disturbed or attacked by male birds in this area (see Section 3.5.2).

Physical health

Mortality

Mortality (i.e., animals who die of natural causes) during the rearing phase has been recorded as 5-7% for females, and 8% for males (EFSA, 2010). Focussed culling (i.e., selective killing) may account for 1-2% of mortality, but the rearing phase mortality is relatively high compared with pullets of commercial egg-laying strains, where mortality during the rearing period is typically less than 3% (Nicol, 2015; Figure 4.3).

Despite the high focussed culling rate of male birds for performance reasons, **it has been estimated that a further 10% of male birds die prematurely during the production phase, resulting in a total male mortality of 25-35%** (Hocking and McCorquodale, 2008; EFSA, 2010). **Total female mortality varies between 4% and 14%** (Hocking and McCorquodale, 2008; EFSA, 2010). Compared with the wide availability of data on mortality and causes of mortality in broilers and laying hens, data for parent birds is very limited. High biosecurity limits infectious disease and feed restriction (see above) reduces the incidence of metabolic conditions. High levels of aggression within some flocks may be a direct cause of some deaths. In support, increased feeder space and lower levels of feed competition during both rearing and production phases have been shown to reduce mortality (Leksrisompong et al., 2014). Overall, recent and reliable information on the level and causes of premature mortality in parent birds is not readily available.

Bone, skeletal and leg health

Commercial laying hens can now be expected to lay approximately 420 eggs over a 70-week period. This places very high demands on the physiological mobilisation of energy and minerals and is a main underlying cause of bone weakness, deformity and keel bone fracture in laying hens. Broiler breeder females have lower rates of egg production, with a typical target being 140-150 eggs over a 40-week period. Nonetheless, this level of egg production remains very high in comparison with traditional breeds or ancestral jungle fowl and it would therefore be expected that parent bird females are also subject to many of the same physiological pressures as commercial laying hens. Gebhardt-Henrich et al. (2017) found keel bone fractures in 39% of Sasso, and 15% of Ross birds but there was no clear influential role of perch provision. These levels are lower than for commercial layer-strain birds but do raise an area of potential concern.

Poor leg health arising from musculoskeletal abnormalities is a significant cause of poor gait and lameness in broiler birds. In the parent birds, feed restriction limits the development of these disorders and leg health is generally thought to be good. However, data are scarce with no readily available information on gait scores in either male or female birds. A concern has been raised about levels of tendon rupture in female parent birds, apparently associated with male aggression (Crespo and Shivaprasad, 2011). In this case study, following an increase in mortality and lameness associated with male aggression, 29 female birds were submitted for post-mortem examination. Half of these birds had experienced a tendon rupture, which was ascribed to trauma resulting from the females' attempts to escape from aggressive males (see section on Aggression, below).

Foot and skin condition

European regulations (2007/43/EC, the Broiler Directive) require official veterinarians to monitor the occurrence of contact dermatitis as part of overall welfare protection for broiler chickens. However, the Broiler Directive does not apply to parent birds and so data on the prevalence and severity of these conditions in parent birds is scarce. Contact dermatitis results from contact of the feet or other areas of exposed skin with wet and dirty litter, resulting in conditions such as footpad dermatitis (FPD), hock burn and breast blisters. Dermatitis can present as small and superficial lesions or as more serious, deep subcutaneous and inflamed ulceration.

Levels of FPD might be expected to be lower in parent birds than commercial broilers because of reduced stocking rates and because parent birds have access to raised slatted and nest box areas in addition to the litter floor. However, a counter influence is the fact that parent birds are kept for far longer periods of time and this could greatly increase the risk. **From the limited studies available it does appear that levels of FPD – including bloody, open and severe lesions – are high in broiler breeder flocks (ranging from 57.8% to 75.6%), and that the risk increases with age** (Renema et al., 2007; Kaukonen et al., 2016; Thøfner et al. 2019). The availability of perches does not increase the incidence of FPD (Gebhardt-Henrich et al., 2018).

Importantly, both Renema et al. (2007) and Thøfner et al. (2019) identified associations between footpad lesions and other indicators of poor health. In particular, Thøfner et al. (2019) calculated that birds with footpad lesions had a 60% higher risk of dying from certain types of bacterial infection than birds with good foot condition.

In contrast to the high levels of footpad lesions observed in parent birds, levels of hock burn have been reported as rare (Kaukonen et al., 2016), probably because parent birds are far more active than commercial broiler chickens and so their hock joints have little contact with wet litter. There is no information on skin lesions on other parts of the body, but again these might be expected to be relatively low due to high parent bird activity.

Concern around the level of footpad lesions observed in parent birds in the few studies conducted so far strongly suggests that routine surveillance of the foot pad condition of parent birds at European slaughterhouses would provide important data and act as a driver to improve welfare.

Aggression

Competitive aggression. Aggression between birds can occur in broiler breeder flocks due to competition in feed-restricted birds (Hocking et al., 2005; Hocking and Jones, 2006). Although overall less aggression is seen in birds fed on 'skip-a-day' regimes than in birds fed a smaller meal every day (Morrissey et al., 2014b) it should be noted that for birds kept on skip-a-day regimes, aggression is higher on the days when no food is provided (Shea et al., 1990).

Aggression around the time of feeding can be addressed by careful attention to reducing competition by, for example, providing sufficient feeder space, or more technical solutions (see text box).

Sexual Aggression. Aggression by males directed at females occurs from the point of mixing, and tends to increase during the early part of the production phase (de Jong et al., 2009). Male birds that have matured early can subject immature females to forced, stressful and potentially injurious copulations (Leone and Estevez, 2008). Male aggression towards females is not only a problem of differential sexual maturity: in many flocks, aggressive interactions and rough sexual behaviour of male birds can persist throughout the production phase. Male birds have been observed to chase and peck females, and to engage in hardly any natural courtship behaviour before forcing copulation (Jones and Prescott, 2000; Millman and Duncan, 2000a,b; Millman et al., 2000; Jones et al., 2001; de Jong et al., 2009). The selection process that has resulted in a lack of courtship behaviour by males is mirrored by a lack of normal sexual crouching response by the females (Jones et al., 2001; de Jong et al., 2009). The consequences for the female birds are injuries to their heads and necks where they have been pecked or pulled by male birds, loss of feathers and injuries to the back and wings resulting from damage by male feet and claws during forced copulations (Millman and Duncan, 2000a; Millman et al., 2000; Jones et al., 2001; de Jong et al., 2009; Moyle et al., 2010). Female birds may try to hide in nests or on slatted areas and may be reluctant to move onto the litter (Millman et al., 2000), thereby foregoing any possibility to engage in normal foraging or dustbathing activities (or drinking if no drinkers are provided on the slats). Although extreme male aggression has rightly been an area of active investigation, much remains unknown. There are indications that both courtship behaviour, forced copulations and aggression are influenced by genotype (Millman and Duncan, 2000b; MCGary et al., 2003). Environmental effects also play a role. Reducing stocking density had a beneficial effect in reducing male aggression in one study, possibly because it allowed male birds more space to perform normal courtship behaviour (de Jong et al., 2012). Adding a UV component to the light provided in the house also resulted in better transmission of visual signals important for natural courtship (Jones et al., 2001).

A potential way of reducing male-to-male and male-to-female aggression is to provide offset barriers on the litter areas of the house. Leone and Estevez (2008) examined the effects of providing offset 70cm-high vertical panels on the central litter areas of commercial

PRECISION FEEDING AS A POSSIBLE SOLUTION FOR AGGRESSION AROUND FEEDING?

Researchers have developed precision feeding techniques with the aim of reducing competition using a novel, non-competitive and sequential precision feeding system for broiler breeders (Zuidhof et al., 2016). As each bird enters a sheltered feeding station it is weighed and food delivered according to growth targets, increasing overall flock production (Zuidhof et al., 2017; 2018). While consuming food, each bird is protected from contact with other birds and can consume several small meals per day. Further work is needed to refine this system as, contrary to predictions, aggression actually increased in the waiting areas in front of the feeding station as birds competed for access (Girard et al., 2017b). Further research into the amount of food delivered per meal, and the time that birds are allocated within the feeding station is also required, as these settings may have an important influence on a bird's levels of satiety or frustration (Girard et al., 2017b).

broiler breeder houses after pilot studies suggested that these could potentially reduce mating competition, aggressive interactions and over-mating of hens (Estevez, 1999). Providing such barriers might also improve bird distribution as there is some evidence that females are sometimes reluctant to use the litter areas where male birds tend to congregate (Millman et al., 2000). In this commercial trial, behaviour was not recorded, but the cover panels increased egg production, fertility, and hatchability, reduced the incidence of floor eggs and increased male dispersal (Leone and Estevez, 2008).

An alternative approach to reduced male-to-female aggression is to separate the male and female birds for a portion of the day, by moving birds towards separate areas at feeding times. Studies have shown flocks kept in such Quality Time Concept housing resulted in improved female plumage condition (suggesting females received fewer aggressive interactions with males). When the sexes were re-mixed, sexual activity was high and there also appeared to be no increase in male-to-male aggression during the period of separation (Van Emous and de Jong, 2013). Careful scrutiny to ensure 100% segregation, and further research into male-female separation systems is necessary. Further research on the current levels of aggression in broiler breeder flocks is also needed as the situation may have changed since the early 2000s, when the majority of studies were conducted, due to further development of genotypes and changes in management practices.

Harmful interventions

Beak trimming

Beak trimming is routinely conducted to avoid damage caused either by injurious feather pecking or during aggressive encounters. Injurious pecking appears to be less of a problem in broiler breeder flocks than in commercial laying hens (Hocking and Jones, 2006; Morrissey et al., 2014a), but it can still occur (de Jong and Guémené, 2011) and the decision to beak-trim may be balanced against the increased risk of injury and infection that can arise when birds have intact beaks. Male birds may also peck and injure females during mating. Infrared beak trimming appears to be a slightly less stressful method of beak trimming, although both methods result in growth setbacks compared with untrimmed chicks (Gentle and McKeegan, 2007; Henderson et al., 2009). Extensive work on laying hen chicks suggests that both methods are painful, although hot blade trimming more so than infrared (Nicol et al., 2013).

Toe clipping and de-spurring

These procedures are conducted on male birds to reduce the damage caused to females during mating, or to other male birds during aggressive encounters. Toe clipping is performed using a hot blade or wire, while de-spurring is conducted by holding the spurs against a hot metal surface. These procedures, conducted without any analgesia or anaesthesia on highly sensitive tissues, will be acutely painful (Gentle and Hunter, 1988). Such procedures may also result in longer-term chronic pain, linked with the formation of benign nerve tumours (neuromas) arising from unregulated nerve regeneration at the end of injured nerve fibres (Gentle and Hunter, 1988). There is a lack of current information or research in this area.

Comb trimming (dubbing)

Removing the comb (or the majority of the comb) of the male birds has been justified as a method of preventing damage due to frostbite or pecking by other birds (as described in FAWC, 1998), or as a way of ensuring that males have an unrestricted view of female birds. However, the combs of modern breeder males are relatively small and probably only a small proportion of male birds are dubbed in response to customer demand (EFSA, 2010). The practice is likely to be painful, as the comb of chicks or young birds is simply cut with scissors. FAWC (1998) argued that the practice had no welfare benefits and should be phased out. There is no reliable information on the extent of this practice in modern broiler breeder production.

Artificial insemination

Artificial insemination (AI) can be used as a management procedure in situations where male birds show low motivation or a tendency to injure females during mating, or where they have physical difficulty (due to large size) in breeding effectively. However, AI requires male birds to be caged and subjected to abdominal massage (to stimulate ejaculation). Repeated handling is likely to be highly stressful (Marin et al., 2001). There are mixed views as to whether the practice of AI is likely to increase. Some scholars have argued that AI could become essential if future genetic selection of males favoured a body conformation that limits physical mating (as is the case in turkeys). However, Laughlin (2009) reported little shift in this direction (Laughlin, 2009). Interestingly, Vegi et al. (2013) found no improvement in the fertility of breeder flocks that were subject to repeated AI after 44 weeks of age, compared to control flocks.

Spiking

In some countries, older males are replaced with younger males around the middle of the production phase in an attempt to maintain fertility levels (EFSA, 2010), a practice that is also known as 'spiking'. Alternatively, older male birds can be swapped between houses on the same premises with the aim of increasing sexual behaviour. Although a relatively common practice, the effects of spiking in improving fertility have been questioned with contradictory findings in the literature. One study found no resultant increase in fertility when either 50% or 100% of old males were replaced with younger birds (Vegi et al., 2013), whereas improvements in fertility were found by Ordas et al. (2015). Even if fertility does increase, there are many drawbacks to the spiking technique including breaches of biosecurity, and increased aggression between males (Chung et al., 2012).

CONCLUSIONS

The major and ongoing welfare concern for parent birds is the use of severe feed restriction to control weight gain and maintain reproductive function. The exact levels of feed restriction that are in current use are not known but it is possible that the severity of feed restriction continues to increase alongside ongoing selection for appetite and growth potential in the broiler bird offspring. This situation requires close scrutiny because, although some of the effects of severe feed restriction can be partially alleviated by altered feeding practices, **the situation can only be resolved by changing selection practices or using alternative genotypes. Genetic selection may also be the best route to resolving problems of aggression within parent bird flocks.** In theory, male birds could be selected for improved and less aggressive reproductive behaviour, and this would in turn reduce the need for harmful procedures such as toe and beak trimming. The current prevalence of aggression and associated injuries within European flocks is not known and obtaining this information would be a necessary prelude to engaging with genetics companies about their breeding goals.

There is a need for data collection on the health and welfare of parent bird flocks worldwide and in the EU. Some practices that have been studied in the USA or Canada (e.g. skip-a-day feeding) are not common or allowed in the EU. Many countries have no studies of broiler breeder flocks at all. Even basic information about current management practices and bird welfare outcomes (such as levels of mortality, or the fate of males not used for breeding) is not openly available. **A major step forward would be the establishment of an independent monitoring and surveillance system to record management practices** (particularly levels of feed restriction) **and key welfare outcomes**, including mortality, plumage, keel bone damage and injury levels. **This would provide a basis from which to engage in dialogue with global genetics companies.**

Optimising animal welfare (a component of sustainability) and the environmental sustainability of parent flocks should become a research priority. The involvement of experts in food systems research can help with this goal and could assess the feasibility of a transition to an EU market where chicken becomes a quality and high-value product, and cheap protein is produced in other ways.

5.
WELFARE OF NEWLY HATCHED BROILER CHICKS

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The Broiler Directive (Council Directive 2007/43/CE) does not currently include minimum standards for the protection of animal welfare in commercial hatcheries, and therefore the welfare of chicks born in such hatcheries falls under the provisions of the General Farm Animals Directive (Council Directive 98/58/EC). In fact, hatchlings (i.e., newly born chicks) are exposed to several animal welfare challenges at a very delicate stage of their lives. Such challenges have both short-term and longer-term impacts that can compromise the health and general wellbeing of the animals. This section describes these challenges and proposes some solutions that should be considered when updating the relevant EU legislation.

5.1
WELFARE CHALLENGES FOR BROILER CHICKS BORN IN COMMERCIAL HATCHERIES

The fertilised eggs from broiler parent birds are most often incubated in specialised hatcheries under controlled temperature, humidity and ventilation. Hatching occurs after 19-21 days of incubation, and the newly born chicks are then exposed to a number of stressors and health challenges, whose duration and severity depend on several variables. The very first stressors include continuous noise, dust, exposure to disinfectants and pathogens, and continuous darkness (Archer and Mench, 2014; de Gouw et al., 2017). Other major stressors are food and water deprivation (Willemsen et al., 2010), handling (Hedlund et al., 2019) and transport (Mitchell, 2009; Jacobs et al., 2017). Such stressors have been studied in more detail as they can have a negative impact on the health welfare of broiler chickens in the short as well as in the long term.

A major welfare challenge is post-hatch food and water deprivation. Typically, even within a same batch, broiler chicks do not hatch simultaneously but over a "hatch window" of 24-48 hours (Careghi et al., 2005). Only at that point are the chicks "pulled" from the incubator, i.e., collected, sorted, and vaccinated to be subsequently transported to the rearing farms, where they will receive food and water for the first time. After hatching, chicks can survive for several hours by utilising the nutrients of the yolk sac (Noy et al., 1996; Lamot, 2017). However, commercial hatcheries do not normally provide newly born chicks with food or water. If chicks are transported over long distances, up to 72 hours can elapse between hatching and arrival on farm, where they will have access to nutrition for the first time. Recently, this practice has been put into question on animal welfare grounds. A study carried out by Wageningen University and Research (de Jong et al., 2017) on the request of the Dutch competent authority found that food and water deprivation in chicks beyond 36 hours significantly increases mortality and impairs growth and feed conversion at a later stage, indicating that welfare may be compromised in the long term, in addition to thirst and hunger in the initial post-hatch period. Taking into account the outcomes of this study, the Dutch competent authority established that chicks must be fed and given water within 36h from hatching.

The second major challenge to chick welfare is handling for transport. Broiler chicks are collected for transport by automated handling systems using a series of conveyor belts. The main factors affecting chick welfare at this stage are conveyor belt speed, acceleration, and drop height between conveyor belts (Giersberg et al., 2020). The process can cause mental and physical stress as chicks experience disorientation, loss of posture, and, occasionally, traumatic injury (Knowles et al., 2004; Giersberg et al., 2020). The severity of such welfare challenges depends on the facilities and management of each specific hatchery, but all in all research has found that handling for transport can decrease broiler chick welfare. The risks increase if the conveyor belts operate at high speeds, if the drop height is excessive or if the maintenance and set up of the facilities are not regularly monitored (Knowles et al., 2004; Giersberg et al., 2020). Studies on laying hen chicks in commercial hatcheries indicate that "rough" handling during collection for transport can cause both short and long-term stress (Hedlund et al., 2019). Besides potentially causing physical damage to the animals this process can also determine fearfulness after handling (Knowles et al., 2004).

Another challenge for newly born broiler chicks is represented by transportation. Hatchery-hatched broiler chicks are typically transported to the rearing farms after a period of feed and water deprivation that starts from hatching. Long transport durations (11 hours) increased the chicks' plasma levels of corticosterone compared to short transport durations (1.5 hours), suggesting a potential stress response (Jacobs et al., 2017). Some authors have also suggested that the cumulative effect of transportation and lack of early nutrition may influence the chickens' ability to cope with stressful events in early and later life as well as their neural and cognitive development (Hollemans et al., 2018), although this merits further study.

Figure 5.1 | On-farm hatching prevents three major stressors encountered by chicks in commercial hatcheries, namely feed and water deprivation, handling and transport. (Image copyright: Vencomatic).

5.2
THE ALTERNATIVES: HATCHERY FEEDING AND ON-FARM HATCHING

Although providing food and water to hatchlings is not yet common practice in commercial hatcheries due to concerns with potential pathogen contamination, some companies have implemented **hatchery feeding**. There are systems on the market[17,18] that provide hatchlings with light, adapted ventilation, feed and water immediately after hatching, thus preventing the disadvantages of delayed post-hatch feeding. Retailers such as Albert Heijn[19], PLUS[20] and REWE[21] have already begun to implement early feeding along some of their supply chains. As demand or early nutrition, some large hatcheries from various EU countries have partially or totally converted to early feeding systems[22,23,24].

Another alternative is **on-farm hatching**, whereby the fertilised eggs are transported from the hatchery to the poultry house a few days before the expected hatching (at 18 days of incubation). Hatching occurs on the same farm where the chickens are reared and the hatchlings have immediate access to food and water (see Figures 5.1 and 5.2 for examples). This hatching method is gradually gaining popularity because it prevents a number of animal welfare issues (de Jong et al., 2019). Specifically, on-farm hatching eliminates the three major stressors we have described above, namely feed and water deprivation, handling, and live transport. Farmers report an improved performance of broiler chickens if they are hatched on-farm compared to commercial hatcheries, and there is preliminary evidence in favour of this solution. Studies have shown that on-farm hatched broiler chickens have better

17 https://www.pasreform.com/en/knowledge/120/post-hatch-feeding-made-easy-practical-and-flexible

18 https://hatchtech.com/hatchery-products/hatchcare/

19 https://www.ah.nl/over-ah/duurzaamheid/dierenwelzijn/kip

20 https://www.plus.nl/info-verantwoord/een-verantwoord-assortiment/onze-kip

21 https://www.rewe-group.com/de/newsroom/pressemitteilungen/1630-early-feeding-fuer-mehr-tierwohl-von-kueken

22 http://www.lagerweybv.com/nl/hatchcare.html

23 https://www.optibrut.de/nl/

24 https://www.probroed.com/en/innovation/

Figure 5.2 | **The X-Treck, an example of an on-farm hatching system. Hatchlings have immediate access to feed and water (Image copyright: Vencomatic).**

growth performances during the first weeks – a very delicate phase for the physiological development of the chicks' digestive, immune, and thermoregulatory systems (Yassin et al., 2009). Studies also indicate that at least during the first weeks body weight of on-farm hatched chickens is increased as compared to traditionally hatched chickens (Hollemans et al., 2018; de Jong et al., 2019, 2020). Additionally, on-farm hatched chickens develop less footpad dermatitis, which is an important animal-based welfare indicator (de Jong et al., 2019) and have lower total mortality (de Jong et al., 2020).

There are various commercial systems available for in-house hatching, which vary in price, degree of automation and design (e.g., the eggs can be placed in trays, boxes or directly on the litter). Some retailers are already carrying out trials with on-farm hatching along their supply chain. This is the case, for instance, of the Colruyt group, who announced that in 2020 and 2021 two of their suppliers would adopt in-house hatching[25].

CONCLUSIONS

There is currently little research on the effects of early feeding in hatcheries compared to on-farm hatching, and this aspect certainly merits further investigation. However, **the available evidence indicates that providing early nutrition to hatchlings is beneficial to their health and welfare. Therefore, early access to feed and water to broiler chicks after hatching is recommended.** On-farm hatching presents a number of animal welfare advantages over hatching in commercial hatcheries: it prevents prolonged feed and water deprivation for hatchlings and it eliminates the many stressors typically occurring in hatcheries, such as exposure to noise, pathogens, disinfectants, handling, as well as the subsequent transport to the rearing units. **Any revision of the applicable EU legislation should include measures to protect the welfare of newly born broiler chicks**, thus being applicable to hatcheries as well as in case of on-farm hatching.

[25] https://www.colruytgroup.com/wps/portal/cg/en/home/stories/chickens-meat-animal+welfare/chickens-meat-animal-welfare

LOOKING INTO THE FUTURE

The previous chapters have illustrated in detail the many, and sometimes severe, animal welfare problems associated with the currently predominant model of chicken production, which is centred on the use of fast-growing breeds. This section presents perspectives for a future for broiler chicken production that is more respectful of animal welfare and at the same time environmentally responsible.

Chapter 6 introduces the current state of play with regards to broiler production in higher welfare systems that use slower-growing breeds.

In **Chapter 7** we outline some considerations about what a sustainable future for higher-welfare poultry production could look like. Within the next six years we would like to witness a massive shift in focus for this industry. The shift should be towards higher welfare standards and slower-growing breeds, accompanied by a clear indication that 'less is better' when it comes to animal products, and chickens should be no exception. A change of pace and mindset is required to fully acknowledge recent scientific findings on broiler chicken welfare, changed societal expectations on the way in which animal-sourced foods should be produced, and market demands and opportunities. These thoughts and some further reflections are summarised in the **Chapter 8**.

The **Annex** presents recent data on the EU poultry meat market, to give an indication of the size of the industry and the number of birds affected.

6. BROILER CHICKEN PRODUCTION USING SLOWER-GROWING BREEDS IN HIGHER-WELFARE SYSTEMS

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The aim of this chapter is to provide an overview of the current knowledge on the welfare status of slower-growing broiler chickens in higher-welfare systems, and to discuss their current and future positioning on the market.

There is an increasing trend in European countries and the US towards the implementation of so-called 'higher-welfare' broiler production systems (CIWF, 2018). This trend will probably further increase as many food businesses have committed to making improvements, e.g. by publicly signing up to the European Chicken Commitment[26]. Some of the 'new' systems have already been present in several countries for years but at a relatively low market share. Examples include organic and traditional free-range systems such as Label Rouge (currently representing 15% of French production[27]), often using slower-growing broiler strains at lower stocking densities and including the provision of an outdoor range.

However, more recently, also so-called 'middle-segment concepts' (Gocsik et al., 2016) have been developed. An example from the UK is the RSPCA Assured production involving slower-growing breeds, lower stocking densities, natural light and environmental enrichment, but without the obligation to have an outdoor range or covered veranda (RSPCA, 2017, RSPCA Assured, 2018; Figure 6.1). In the Netherlands, in 2007 a free-range indoor system was developed in cooperation with the Dutch Society for the Protection of Animals, involving slower-growing breeds, lower stocking densities, natural light, some environmental enrichment and a covered veranda

Figure 6.1 | **Higher-welfare broiler production systems typically use slower-growing breeds and environmental enrichment, among other features. Image copyright: RSPCA.**

26 https://welfarecommitments.com/europeletter/

27 https://www.volaille-francaise.fr/wp-content/uploads/rapport2018chiffres-cles.pdf

(Ellen et al., 2012; Saatkamp et al., 2019). More recently, since 2014, there has been a substantial shift from standard intensive broiler production to higher-welfare systems in the Netherlands, because retailers set requirements for fresh chicken in their 'Kip van Morgen' (Chicken of tomorrow) standards (Saatkamp et al., 2019). This resulted in a current market situation of 30-40% of the broilers in the Netherlands being of a slower-growing strain (Van Horne, pers. comm.; see Text box below). The 'Kip van Morgen' requirements involve the use of a slower-growing breed, reduced stocking densities as compared to conventional systems, providing environmental enrichment and an uninterrupted dark period of 6 hours (Saatkamp et al., 2019).

THE TRANSITION TO HIGHER-WELFARE BROILER FARMING IN THE NETHERLANDS

The process of transition in the Netherlands from standard intensive broiler systems to production concepts with higher welfare requirements has been described by Saatkamp et al. (2019). Until 2014 only a small part of the broiler farms in the Netherlands produced meat with higher welfare requirements. As of 2014-2015, the broiler production sector changed considerably, towards all fresh meat produced for the retailers under higher welfare requirements. Currently, 30-40% of the broiler chickens present in the Netherlands meet these retail standards or even higher welfare requirements. Analysis of the process revealed that there were five important factors playing a role in this change: (1) the availability of a cost-efficient alternative to conventionally produced meat; (2) a basic willingness to change within the entire value chain (including consumers); (3) initiating and triggering actions by non-governmental organisations (NGOs); (4) decisive initiatives by retailers; and (5) simultaneous introduction of the new concept replacing the conventional concept in supermarkets (i.e., depriving the consumer of a cheaper choice alternative).

6.1 DEFINITIONS OF SLOWER-GROWING BREEDS AND WELFARE-FRIENDLY BROILER CHICKEN PRODUCTION

Slower-growing broiler breeds are here defined as broiler chickens produced from a slower-growing female crossed either with a standard fast-growing or with a slower-growing male. These chickens require a longer rearing period to achieve the desired slaughter weight, usually between 49 and 81 days of age (middle-segment to organic broiler production) as opposed to 35 – 42 days in conventional broiler production. Slower-growing broilers usually have a daily growth rate of 50 g/day or lower (Saatkamp et al., 2019, RSPCA Assured, 2018). By contrast, conventional, fast-growing chickens have a growth rate of above 65 grams/day, meaning that they achieve a slaughter weight of about 2.5kg in just 38 days (Aviagen, 2019, Cobb, 2015).

There is within- and between-country variation in guidelines for higher-welfare systems using slower-growing breeds, together with a substantial variation in length of the rearing period and daily growth rate of the different broiler strains used. This variability has an impact on animal welfare outcomes. Bracke et al. (2019a) found that experts assigned relatively low overall welfare scores to conventional broiler production systems in the US and the EU (3.7 and 2.9 respectively on a scale from 0 to 10), but also assigned relatively low scores to the organic US and Dutch retail ('Chicken of tomorrow') concepts (average scores ≤ 5.8). In contrast, systems like Label Rouge, Free range EU, Free Range Indoor (Better Life label one star from the Dutch Society for the Protection of Animals) and Organic EU received scores of ≥ 7.0. Experts used both input (housing and management conditions) and output factors (welfare outcomes) to evaluate the different systems. According to the experts, health status, stocking density, litter quality and enrichment were the main variables contributing to improved welfare. Systems presented as welfare-friendly may, thus, vary in the degree to which they meet that objective, according to the broiler welfare experts.

In the present chapter we define higher-welfare systems as systems using a slower-growing broiler strain, kept at stocking densities of 38kg/m^2 or lower and (at least some) additional environmental enrichment in the house in addition to litter. These parameters, *per se*, do not necessarily guarantee a sufficient level of animal welfare (Bracke et al., 2019a), but have the potential to provide better welfare as compared to the standard, conventionally reared fast-growing broiler strains.

6.2 WELFARE OF SLOWER-GROWING BROILER BREEDS

Conventionally reared, fast-growing breeds of broiler chickens have been intensively selected for efficient growth and high meat yield at slaughter (Zuidhof et al., 2014; EFSA, 2010). However, as seen in previous chapters, this has also resulted in health and welfare problems, such as impaired leg health (lameness, foot pad lesions, hock burns), metabolic diseases, and other health problems that result in the need for antibiotic treatments. Additionally, fast-growing birds are often intrinsically prevented from performing normal behaviours such as locomotion, foraging and perching (Bokkers and Koene, 2003; EFSA, 2010; de Jong et al., 2012; RSPCA, 2020). Animal welfare improvements can be obtained by including welfare indicators in the selection index. This is already done by breeding companies for some welfare indicators in some genetic lines, but the priority attributed to such welfare traits remains relatively low (RSPCA, 2020). Nevertheless, breeding companies have been successful in selecting against susceptibility for ascites, sudden death syndrome and some leg health aspects, of which the incidence in fast-growing lines is now significantly lower than it was 20 years ago (Hiemstra and Ten Napel, 2011). Therefore, further progress appears within reach. **Slower-growing strains are generally considered to be less sensitive to develop welfare problems and are better able to show the elements of natural chicken behaviour** (EFSA, 2010). Literature comparing the welfare of fast and slower-growing breeds housed under similar conditions and management, which is necessary for a proper scientific comparison, used to be relatively scarce until recently. However, very recently, new results have become available showing that slower-growing strains have a better potential for improved animal welfare compared to fast-growing strains (see box on this and the next page).

ANIMAL HEALTH AND WELFARE OUTCOMES IN FAST- AND SLOWER-GROWING BROILER BREEDS

More than 15 years ago, researchers compared one slower-growing Hubbard strain with a fast-growing Cobb strain, managed and housed under similar conventional conditions to an equal slaughter weight (42 days for the fast-growing and 56 days for the slower-growing strain). They found that the slower-growing strain had a significantly lower mortality (mainly caused by fewer heart and circulation problems), a significantly improved walking ability, significantly less contact dermatitis (breast irritation, hock burn and footpad dermatitis) and significantly less thigh scratches as compared to the fast-growing broiler strain (Van Middelkoop et al., 2002). These findings were confirmed in a later study by Rodenburg et al. (2004) comparing fast-growing Ross 308 with slower-growing Hubbard chickens housed under similar conditions (conventional and extensive with outdoor range for both strains). More recently, Wilhelmsson et al. (2019) compared fast-growing Ross 308 with slower-growing Ross Ranger broilers housed under organic conditions (without an outdoor range) and reared until 10 weeks of age. The fast-growing broilers showed impaired gait score, had more contact dermatitis, heat stress and mortality as compared to the slower growers, especially beyond 6 weeks of age. Genotype associated with growth rate has been shown to be a major determining factor in the prevalence of lameness (Knowles et al., 2008). Significantly less lameness is seen in slower-growing strains (Rayner et al., 2019, Knowles et al., 2008). When housed under similar conditions, slower-growing broiler chickens are more active than fast-growing ones, especially in the second half of the rearing period (Bokkers and Koene, 2003; Nielsen et al., 2004; Rodenburg et al., 2004; Dal Bosco et al., 2010; Wallenbeck et al., 2016; Rayner et al., 2019; Torrey et al., 2019). This may partially explain differences in walking ability and contact dermatitis between fast- and slower-growing breeds. Slower-growing chickens make better use of provided enrichments such as elevated platforms (Riber et al., 2018; Malchow et al., 2019) and an outdoor range (Rodenburg et al., 2004, Dal Bosco et al., 2010). Higher activity in slower-growing broiler breeds compared to fast-growers was already observed in the first days of life, suggesting a genetic effect on bird activity (Bizeray et al., 2000; Nielsen et al., 2010). A study carried out by Dixon (2020) assessed the health, welfare and meat quality outcomes of three of the most commonly used fast-growing broiler breeds compared to the outcomes of one slower-growing breed. All birds were reared under exactly the same conditions. The results showed that the fast-growing breeds had consistently worse health and welfare outcomes, with more hock burns, lameness, more time spent sitting vs. foraging, and less time spent dustbathing and perching. In addition, the breasts of fast-growing birds presented a higher prevalence of meat quality problems (white striping and woody breast) that may also affect animal welfare as they are due to muscular degeneration and inflammatory processes. Another study by Caldas-Cueva and Owens (2020) confirms that meat quality problems due to conditions such as woody breast are causing significant economic losses to the conventional meat poultry sector. The authors suggest that these meat quality problems are likely associated with selection for rapid growth rates and high yields in broiler chickens. In a study comparing broiler welfare in four conditions representing different commercial systems, Rayner et al. (2020) also concluded, based on on-farm evidence, that using slow-growing breeds is the one most important factor to improve broiler chicken welfare. Very recently, scientists involved in *"the largest and most comprehensive study of broiler chicken welfare worldwide by University of Guelph researchers"*, which will soon be available in peer-reviewed journals, concluded that *"raising slower-growing broiler chickens may improve the welfare of millions of birds"*.[28]

[28] https://news.uoguelph.ca/2020/09/u-of-g-researchers-prove-slow-growing-chickens-more-humane-in-groundbreaking-study/

6.3 WELFARE STATUS OF SLOWER-GROWING BROILERS IN HIGHER-WELFARE SYSTEMS

Only a few studies have been carried out under commercial conditions to assess the welfare outcomes of slower-growing breeds in higher-welfare systems in comparison to conventional indoor systems rearing fast-growing breeds. These are not the most recent studies, but they present the general and still valid point that higher-welfare systems present a reduced risk of welfare problems. Table 6.1 shows the specifications of the production systems that have been compared to date and Table 6.2 summarises the main welfare outcomes. Although Table 6.2 shows considerable variation, both in the conventional as in the higher-welfare system, the figures in Table 6.2 also confirm that several key welfare indicators, such as footpad dermatitis, hock burn, walking ability and mortality, are (indeed) better in higher-welfare systems with slower-growing breeds than in conventional broiler systems with fast-growing breeds.

Table 6.1 | Specifications of five studies comparing conventional broiler production with higher-welfare systems using slower-growing breeds, of which average welfare outcomes are presented in Table 6.2.

Aspects of study	Fast-growing strain in conventional system	Higher-welfare system with slower-growing strain	Reference
Breed	Ross 308	Cobb Sasso 175A	(Bergmann et al., 2016)
Stocking density	34.9kg/m²	28.7kg/m²	
Enrichment	No	Perches, pecking stones, straw bales	
Daylight in the house	Yes	Yes	
Outdoor access	No	Covered veranda	
Study design	6 production cycles on 2 farms	Idem ('German animal welfare label')	
Country	Germany	Germany	
Age at assessment	Day 35	Day 40	
Breed	Ross	Hubbard	(de Jong et al., 2011)
Stocking density	43kg/m²	25kg/m²	
Enrichment	No	Bales, wheat scattering	
Daylight in the house	No	Yes	
Outdoor access	No	Covered veranda	
Study design	123 flocks (34 farms)	30 flocks (18 farms) ('Better life one star' or 'Volwaard')	
Country	Netherlands	Netherlands	
Age at assessment	Day 36 (1-5 days before depopulation)	Day 53 (1-5 days before depopulation)	
Breed	Ross 308, few Cobb 500	Hubbard JA757	(de Jong et al., 2015)
Stocking density	39-42kg/m²	25kg/m²	
Enrichment	No	Bales, wheat scattering	
Daylight in the house	No	Yes	
Outdoor access	No	Covered veranda	
Study design	154 flocks on 40 farms	40 flocks on 10 farms ('Better life one star')	
Country	Netherlands	Netherlands	
Age at assessment	Day 37 (1-5 days before depopulation)	Day 51 (1-5 days before depopulation)	
Breed	Ross 308, few Cobb 500	Hubbard JA757	(Gerritzen et al., 2019)
Stocking density	39-42kg/m²	33kg/m²	
Enrichment	No	Bales, wheat scattering	
Daylight in the house	No	Yes	
Outdoor access	No	No	
Study design	9 flocks	8 flocks ('Chicken of Tomorrow')	
Country	Netherlands	Netherlands	
Age at assessment	Day 38 (1-5 days before depopulation)	Day 49 (1-5 days before depopulation)	

Aspects of study	Fast-growing strain in conventional system	Higher-welfare system with slower-growing strain	Reference
Breed	Fast-growing	Slower-growing, max 45g/day	(RSPCA, 2006)
Stocking density	36kg/m^2	29kg/m^2	
Enrichment	No	Straw bales, perches, pecking objects	
Daylight in the house	No	No	
Outdoor access	No	No	
Study design	128 flocks on 14 farms ('Red Tractor')	68 flocks on 18 farms ('RSPCA Assured')	
Country	UK	UK	
Age at assessment	39 days	50 days	

Table 6.2 | Comparison of welfare indicators between conventional broiler systems using a fast-growing breed and higher-welfare systems with a slower-growing breed (see Table 6.1 for specifications of the systems). Four studies (de Jong et al., 2011, 2015; Bergmann et al., 2016; Gerritzen et al., 2019) applied the Welfare Quality® broiler assessment protocol (Welfare Quality, 2009), i.e. included walking ability and scored footpad dermatitis and hock burn into 5 categories. The RSPCA study examined total proportions of hock burn and footpad lesions (RSPCA, 2006).

Welfare indicator	Fast-growing strain in conventional system	Higher-welfare system with slower-growing strain	Reference
Footpad lesions			
% mild lesions	15.7	2.5	(Bergmann et al., 2016)
	31.6	17.2	(de Jong et al., 2011)[2]
	13.4	5.3	(de Jong et al., 2015)[3]
	13.4	4.4	(Gerritzen et al., 2019)
% severe lesions	1.2	0	(Bergmann et al., 2016)
	32.7	8.3	(de Jong et al., 2011)[2]
	22.9	4.4	(de Jong et al., 2015)[3]
	45.1	0.7	(Gerritzen et al., 2019)
% total (mild + severe)	**6.5**	**3.5**	**(RSPCA, 2006)**
Hock burn			
% superficial	33.4	20.3	(Bergmann et al., 2016)
	45.0	19.2	(de Jong et al., 2011)[2]
	30.4	15.8	(Gerritzen et al., 2019)
% severe	1.8	0	(Bergmann et al., 2016)
	16.5	2.0	(de Jong et al., 2011)[2]
	21.5	1.33	(de Jong et al., 2015)[3]
	5.23	0.22	(Gerritzen et al., 2019)

Welfare indicator	Fast-growing strain in conventional system	Higher-welfare system with slower-growing strain	Reference
% total (mild + severe)	**19**	**3.5**	**(RSPCA, 2006)**
Walking ability			
% gait score ≥ 3 (moderate to severe lameness)	24 65.2 55.0 66.8	1 18.5 3.8 15.0	(Bergmann et al., 2016) (de Jong et al., 2011)[2] (de Jong et al., 2015)[3] (Gerritzen et al., 2019)
Total mortality %[1]	3.5 2.7 2.8 3.7 5.1	3.4 3.4 1.6 1.9 1.8	(Bergmann et al., 2016) (de Jong et al., 2011)[2] (de Jong et al., 2015)[3] (Gerritzen et al., 2019) (RSPCA, 2006)

[1] Note that mortality levels were calculated over the whole rearing period, which was longer in higher-welfare as compared to conventional indoor systems (see Table 6.1); generally, daily mortality was lower in the higher welfare systems

[2] Of this study, only data collected in 2011 in the Netherlands are presented (see Table 6.1)

[3] Data were collected within this study, but average figures have not been published earlier.

Very little data has been collected on the performance of behaviour in higher-welfare systems versus conventional systems under commercial conditions. To our knowledge, only Bergmann et al. (2017) compared the behaviour of 6 flocks of fast-growing broiler chickens in a conventional indoor system with 6 flocks of slower-growing broiler chickens in a higher-welfare system, with lower stocking density, a covered outdoor range and environmental enrichment. They found that the chickens were significantly more active in the higher-welfare system (more locomotion, foraging and comfort behaviour in the higher-welfare system), confirming the results of studies under experimental or semi-commercial conditions (Bokkers and Koene, 2003; Nielsen et al., 2004; Rodenburg et al., 2004; Dal Bosco et al., 2010; Wallenbeck et al., 2016; Rayner et al., 2019; Torrey et al., 2019; Dixon, 2020). Higher-welfare systems with slower-growing breeds may differ in their specifications, e.g. in the Netherlands stocking densities in such systems vary between 25 and 38kg/m^2, growth rates between 45 and 50g/day, and only some systems have windows or a covered outdoor range (Vissers et al., 2019). Therefore, more research is required to compare systems having different specifications examining both behaviour and other welfare indicators, to get more insight in the actual welfare status in different broiler housing systems.

6.4 COST EFFECTIVENESS

Gocsik et al. (2016) and Vissers et al. (2019) calculated the costs of different welfare-friendly broiler systems as compared to the legal minimum requirements, i.e. fast-growing broiler chickens in conventional indoor systems. They used data collected with the Welfare Quality® protocol (Welfare Quality, 2009) and expert consultation to calculate the relative costs of welfare improvement of various broiler production systems, and modelled these for different countries such as the Netherlands, US and Brazil. Their studies clearly showed that higher-welfare broiler systems involve higher production costs, mainly increased feed costs. Slower-growing breeds are less efficient in converting feed into meat, i.e. they need more feed to grow to slaughter weight. In particular in organic production systems, the standards for feed production involve substantial additional costs (e.g. from not using pesticides). However, these studies have also notably shown that 'middle-segment systems', i.e. higher-welfare systems that are intermediate between the conventional production and organic production, have relatively favourable cost-benefit efficiency. These middle-market systems obtained a relatively large welfare gain as compared to conventional production with fast-growing strains, at a relatively limited cost. In this study, middle-segment systems even obtained a

higher absolute welfare score (Welfare Quality® index score) than the organic production system (Gocsik et al., 2016), but this was probably due to the more variable environmental conditions in organic systems (e.g. wet soil in the outdoor range and/or reduced climate control inside the building due to open pop holes).

One final aspect deserving consideration concerns mortality (due to culling or death). Broiler chicken mortality has recently been assessed to be on average 1% higher when using fast-growing breeds (ADAS, 2019). Higher mortality rates, besides being an animal welfare problem, may constitute a loss of income for farmers. By contrast, lower broiler chicken mortality and a more pleasant working environment for operators can be considered benefits in higher-welfare broiler rearing systems (ADAS, 2019).

Investment risks for conventional farmers to adopt such 'middle-segment' systems are also **relatively low**, as they can be created by adapting existing buildings whereas adopting a more extensive production system requires more costly investments (e.g. an outdoor range or veranda). Thus, intermediate systems provide opportunities for a more welfare-friendly, indoor broiler production on a global scale. If we consider the status quo in socio-economic terms, the currently high competitiveness in broiler production means that such changes will become mainstream if the higher costs are compensated by premium prices (Vissers et al., 2019). Producing for a specific concept can then also be beneficial for farmers, as there is less need to compete for the lowest price on the international market, and longer-term contracts can be negotiated. Willingness of consumers to pay higher prices for better broiler welfare will differ between countries, and, at least in Western countries, societal pressure seems to be an important driver for changes (CIWF, 2018). Examples are the recent developments in the Netherlands towards the higher-welfare retail concepts that were mainly driven by societal pressure (Saatkamp et al., 2019). By contrast, the demand for affordable animal proteins seems to be the most important driver in developing countries (Vissers et al., 2019; Bracke et al., 2019b), where an apparently 'reverse' development may take place as indicated, for example, by an interest in rearing broilers in (colony) cages (e.g. the Philippines and Indonesia, Bracke et al., 2019b). This is a welfare concern as experts assigned very low scores to a system of rearing broilers in cages (Bracke et al., 2019a). The experts gave the 'battery cage' an average score of 1.3, and an idealised 'modern cage' (with on-farm hatching and automated harvesting) still only achieved an average score of 2.9 on a scale from 0 to 10.

6.5
USE OF ANTIMICROBIALS

Slower-growing broilers are considered to be less liable to develop health problems (EFSA, 2010), **which is not only beneficial for the welfare of the chicken itself, but also has positive effects on public health through a reduced use of antibiotics in production systems with slower-growing broiler strains**. Records of antibiotics usage in the Netherlands between 2014 and 2018 have shown that 91-94% of flocks with slower-growing broilers did not receive any antibiotic treatment, whereas 67-72% of the conventional fast-growing flocks were free of antibiotics treatments. Similar differences were found for the rearing phase of parent birds in 2018 (no information is available for other years): 53% of conventional parent birds was reared without antibiotic treatments versus 78% of parent birds of slower-growing strains. However, during the production phase of parent birds, antibiotic usage was slightly higher in parent birds of slower-growing strains (81% antibiotics-free flocks of slower-growing strains, versus 85% antibiotics-free flocks of conventional strains) (Avined, 2019).

CONCLUSIONS

The current state of welfare science outlined in the previous section shows that **animal welfare is likely to be improved by using slower-growing broilers in higher-welfare systems because they experience less pain or stress**. Reduced lameness, mortality (RSPCA, 2006; de Jong et al., 2011; de Jong et al., 2015; Bergmann et al., 2016; ADAS, 2019; Gerritzen et al., 2019; RSPCA, 2020) and rejection percentage at the slaughter plant (RSPCA, 2006; 2020), reduced antibiotic treatments in slower-growing broilers (Avined, 2019) and improved reproduction efficiency, absence of hunger, thirst and less health problems in the parent birds (Decuypere et al., 2010) lead to improved welfare, as well as to reduced losses in the chain and, in the case of antibiotic treatments, reduced risks for human health from using slower-growing breeds. Given the variety in higher-welfare systems and the limited data available, a focus on the actual welfare performance of broilers in the different types of system will help to guide decisions about which systems are most acceptable in view of changing societal expectations on animal-sourced foods, while also truly delivering in terms of animal welfare and contributing to the global fight against antimicrobial resistance.

7.
TOWARDS A FUTURE-PROOF HIGHER-WELFARE BROILER CHICKEN SECTOR

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Key messages

- Sustainability is a multi-faceted concept that incorporates environmental impacts, social and economic considerations
- Slower-growing broiler breeds and higher-welfare systems can improve their environmental sustainability with a targeted genetic selection of the parent birds and by feeding birds with safe and certified by-products
- Businesses, finance institutes and investors also play a major role in driving change for animal welfare
- For as long as poultry meat will be consumed and obtained from live animals, a shift towards 'less and better', produced more humanely, with care for the environment, and with the right remuneration for farmers, seems to be the best strategy to meet societal concerns and our current knowledge of what chickens need to lead a 'good life'

7.1
THE SUSTAINABILITY OF HIGHER-WELFARE BROILER SYSTEMS

Defining sustainability

Sustainability is a multi-faceted concept that incorporates several aspects, typically identified as social, economic, and environmental. In particular, when applied to animal production systems, the treatment of animals is often an important aspect in discussions around sustainability. Tallentire et al. (2019) state that: *"For a production system to be sustainable, it should be economically viable, contribute to the equitable management of resources, be embedded in its socio-cultural context, and be respectful towards both humans and non-human animals"*. In another overview of animal welfare and sustainability, Buller et al. (2018) conclude that, thanks to the convergence of scientific knowledge, NGO advocacy, and targeted marketing campaigns, farmed animal welfare is now firmly embedded in the expectations of European citizens as well as in European public policy. Consequently, at least in the EU, the concept formalised by Broom (2019) holds true, namely that *"A system or procedure is sustainable if it is acceptable now and if its expected future effects are* *acceptable, in particular in relation to resource availability, consequences of functioning and morality of action"*. In this sense, sustainability is linked to what is morally acceptable to a given group of social actors, taking into account the local cultural and geographical context. The animal-source food supply chain will have to adapt and find solutions to address these concerns. Animal welfare in the narrow sense includes both the ethical treatment of animals (from a human point of view), and the aspects of animal welfare that matter to the animals themselves, from their point of view. However, we argue that the increasing criticism towards intensive livestock farming stems from animal welfare concerns in a wider sense, including both non-human animal welfare as well as human-animal welfare, in line with the OneWelfare framework.

Managing the environmental footprint of different broiler production systems

Poultry meat is the most popular animal-sourced food in the EU. Over 16 million tonnes are produced domestically and large volumes are being exported (European Commission, 2019). There is an upward trend for production, albeit with concern for the ability to deliver adequate profits for farmers (Rabobank, 2019). The strength of the sector currently lies in the short production cycle when using fast-growing broiler breeds (only 35-42 days) coupled with a more efficient use of resources compared to other livestock sectors, whereby chicken meat achieves a lower environmental footprint than other types of meat, such as beef and sheep (Clark et al., 2019).

The relatively few studies comparing the environmental sustainability of higher-welfare broiler rearing systems with conventional systems (Leinonen et al., 2012, Leinonen et al., 2014; Tallentire et al., 2017; Van Wagenberg et al., 2017; ABN AMRO, 2018) conclude that – in the absence of specific mitigation measures – higher-welfare broiler production systems can have a negative impact on the global warming potential (GWP). The extent of the GWP depends on the specific system studied, namely higher-welfare indoors, free-range, or organic. The higher environmental footprint is due to the longer rearing cycle of slower-growing breeds, which causes a higher consumption (and production) of feed, as well as higher running costs, i.e., gas, oil, and electricity.

It should also be noted that the rearing of parent birds has historically not been included in most calculations. A recent Dutch report commissioned by the Dutch Society for the Protection of Animals (Dierenbescherming, 2019) suggests that with different modelling assumptions, the environmental impact of higher-welfare production might not be higher than conventional production in all respects. For instance, ammonia emissions are lower in systems using slow/intermediate growth broiler breeds if the broiler parent bird production phase is also taken into consideration. Parent flocks from slower-growing breeds produce more eggs and consume less feed (ADAS, 2019). Additionally, as noted by Dixon (2020), when calculating the relative environmental impacts of fast-growing versus slower-growing poultry systems, the higher losses due to mortality and meat quality downgrades in systems using fast-growing breeds have not always been taken into account. **Genetic selection can be beneficial in achieving better chicken welfare while also meeting other sustainability aspects**. Using a female parent of a dwarf breed to produce slower-growing broiler chickens has beneficial effects on feed efficiency, reproduction performance (Decuypere et al., 2006) and emissions (Van Emous, 2019) as compared to conventional parent birds.

The industry is proactively experimenting with solutions that aim at meeting citizens' concerns about animal welfare with improved environmental sustainability: one example is the Windstreek farm[29] developed by the Plukon Food Group in the Netherlands. This

[29] https://youtu.be/Taog31M6HKA

concept farm, which won the "Best Innovation Award 2016" of Compassion in World Farming, combines the standards of the Better Life (Beter Leven) assurance scheme with technological solutions to optimise the use of energy and lower the emissions of noxious gases and fine particulate matter[30]. As is the case with any innovative project, studies are still ongoing to assess the animal welfare outcomes of the adopted strategies under different climatic conditions.

In sum, a more holistic approach, the proactive involvement of the industry, and further research on the whole broiler supply chain will be required to optimise the environmental sustainability of higher-welfare systems. As feed has the largest impact on GWP, **feeding safe and certified by-products or residues will have a beneficial effect on the GWP** (Elferink et al., 2008, Leinonen et al., 2013) and is an essential part of a circular agriculture, a concept that will be further discussed below. Other examples of how this can be achieved include, for instance, the **reduction of waste at all stages of production, better carcass use, new product development, blended products** and consumer **information and education on the use of all parts of the carcass.**

Societal demands will play a major role in driving change for broiler chickens, in particular concerning the acceptability of genetic selection for fast growth and of the intensive rearing conditions described in previous chapters. This will require an increased awareness of the importance of integrity, i.e., a more open and honest attitude, along the entire supply chain, about the current reality and what is (morally) right when dealing with the rearing of live animals. Eventually, the whole chicken supply chain will have to adopt strategies to optimise the environmental impact of higher-welfare broiler chicken production systems to meet these evolving societal expectations.

The wider availability of affordable, nutritious and tasty alternatives (plant-based, cell-based, etc.) coupled with information campaigns about sustainability and the increasing willingness by EU consumers to pay a premium price for higher-welfare productions (Dixon, 2020) will be other key factors that may accelerate a shift away from the predominant model relying on fast-growing breeds.

[30] https://www.plukon.be/duurzaamheid/windstreek/

7.2 MARKET FORCES DRIVING CHANGE FOR BROILER CHICKENS

Animal welfare is an important societal value in the EU (European Commission, 2016). However, consumers are not and should not be the sole actors responsible for driving better animal welfare practices in animal agriculture. **Businesses, finance institutes and investors also play a major role in driving change for animal welfare.** Indeed, this is happening and is becoming increasingly apparent, as shown by initiatives such as the Business Benchmark for Animal Welfare (Amos and Sullivan, 2017), the FARMS Initiative[31], and the Global Coalition for Animal Welfare[32]. Since 2012, the Business Benchmark for Animal Welfare has been providing companies *"with a clear set of expectations on farm animal welfare management practice and reporting, enabling them to benchmark themselves against industry peers and to progressively drive up welfare standards in their supply chains"* (BBFAW, 2020). The BBFAW is designed so that investors can make informed decisions about the animal welfare policies of businesses they are considering for investment (Sullivan et al., 2017).

The commitments of food companies are major driving forces to influence the welfare of animals, especially if the commitments expressed are translated into actual behaviour and achievements (Sullivan et al. 2017). This type of information is becoming increasingly important for investors: another example is the FAIRR initiative, established by the Jeremy Coller Foundation, a *"collaborative investor network that raises awareness of the material ESG risks and opportunities caused by intensive animal production investors"*[33]. Specifically, for broiler chickens, the new responsible minimum standards for financing institutions published by the FARMS Initiative (a coalition of animal welfare organisations) use the criteria of the European Chicken Commitment[34] as minimum standards that should guide investors interested in investing in new poultry businesses. This requires using only slower-growing breeds and providing better rearing, transport, and slaughter conditions for broiler chickens.

[31] https://www.farms-initiative.com/

[32] http://www.gc-animalwelfare.org/

[33] https://www.fairr.org/

[34] https://welfarecommitments.com/letters/europe/fr/

Big multinationals are not only spectators of this movement, but they are profiling themselves as being co-drivers of change, as shown by the Global Coalition for Animal Welfare (GCAW). GCAW is *"the world's first industry-led collaboration aimed at advancing animal welfare globally"* and gathers players of the calibre of Nestle, Unilever, and IKEA's food business as well as big names in catering. The Coalition has already started with engaging their broiler supply chain partners in working towards higher-welfare broiler meat. The proceedings of a workshop dedicated to this topic are available on their website (GCAW, 2019).

Last, but not least, **animal welfare is an integral component of the UN Sustainable Development Goals** (SDGs). Keeling et al. (2019) examined the extent to which achieving the UN SDGs is compatible with improving animal welfare, by asking 12 experts to score independently the link between the SDGs and animal welfare. They found good consensus between participants, with the overall scores being positive, indicating that although animal welfare is not explicitly mentioned in the SDGs, working to achieve the SDGs is compatible with working to improve animal welfare. Going a step further, it can be argued that improving animal welfare will contribute to achieving several of the SDGs (Ghislain et al., 2019), and that animal welfare should be added as the 18th SDG (Visseren-Hamakers, 2020). This is in line with the OneWelfare concept (Pinillos et al., 2016). Animal welfare, like sustainability, is not a stable state. Rather, it is a process, something to be improved upon over time.

7.3 POULTRY PRODUCTION AS PART OF A CIRCULAR OR REGENERATIVE AGRICULTURE MODEL

In the Netherlands, the second largest agricultural exporter in the world after the US (DutchNews.nl, 2018), a transition process has started away from intensive livestock farming towards a circular agriculture (LNV, 2018). The aim of the circular agricultural model is to close nutrient cycles, in order to deal with issues related to ecology and the need to feed the growing world population of humans. Broiler farming systems, including higher-welfare concepts, have relatively low feed conversion ratios, at least when compared to most other farmed vertebrates. This can be regarded as an important advantage for sustainability (Leinonen and Kyriazakis, 2016), as the better the feed conversion ratio the more land can be made available for other sustainability goals (especially ecology-related, but in principle also welfare-related, i.e. by providing lower stocking densities and outdoor access). However, part of the high feed efficiency of poultry farming may be related to the fact that it depends on feed that is relatively well suited as food for humans (grains, corn), using relatively few by-products. Thus, **poultry production is currently competing with edible resources for humans** (Leinonen and Kyriazakis, 2016). In the future, the competition between humans and animals for nutrients ("feed-food competition"; Van Zanten et al., 2018) will have to be gradually eliminated. Thus, poultry feed will increasingly need to be composed of by-products. Additionally, human diets, especially in the developed part of the world, will have to be more plant-based, with reduced animal protein intake compared to current levels of consumption: people in high-income regions are currently consuming both too much protein in general, and too much animal protein in particular (Van Zanten et al., 2018). Calls for a drastic reduction of the intake of animal products and for a transition towards agro-ecological systems are coming from different sectors of civil society (environmental organisations, animal advocates) as well as scientific panels (IPCC, 2019; IPES-Food, 2019). The EU Farm to Fork strategy (European Commission, 2020), part of the European Green Deal, includes strong language on the need for such a transition as well as several action points. Animal welfare organisations and environmental organisations are now aligned in calling for decisive policies to tackle the overconsumption of animal products in the EU (Greenpeace EU, 2020; Munić et al., 2020).

The transition towards a circular-agriculture model based on agro-ecological principles will hopefully generate opportunities and benefits for animal welfare, e.g. if farming systems are designed to be more in line with the behavioural requirements of the various farmed animal species. Such a transition should not, however, take the direction of further intensification of production (Shields and Orme-Evans, 2015) or use animals solely as means to close nutrient cycles (RDA, 2020). Reverting to using more resilient, traditional breeds instead of the prevalent highly productive strains could facilitate the shift towards using lower-quality feed that is not suited for human consumption (by-products). Another concern regarding circular agriculture is that it may also 'circulate' animal and human safety risks such as toxins and contagious diseases (Stegeman et al., 2019). Being aware of these concerns is important to move towards a model of circular agriculture that not only improves biological nutrient cycles, but also improves biodiversity via regenerative, nature-inclusive farming, and animal welfare, with full satisfaction of behavioural and welfare needs, including the expression of natural behaviour and the preservation of physical integrity.

CONCLUSIONS

Higher-welfare systems using slower-growing broiler breeds can coincide with sustainable broiler meat production, even if they are currently considered less economically and environmentally efficient than conventional systems using fast-growing birds. Changing societal expectations about the moral status of farmed animals and the close interconnection between animal and human welfare should be taken into account in promoting a shift towards higher-welfare broiler systems. Additionally, improving animal welfare is compatible with the UN Sustainable Development Goals. Recent developments towards a circular agriculture call for resilient animals consuming lower-quality by-products, and together with the trend of decreased use of animal-based proteins in human diets, this offers opportunities for implementation of higher-welfare broiler production systems using slower-growing strains.

ANIMAL WELFARE AND ETHICS IN THE CONTEXT OF SUSTAINABLE PRODUCTION

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In order to discuss broiler welfare within the broader context of sustainable production, the first thing to note may be that animal welfare does not seem so far to have had a 'natural' place to fit in the concept of sustainability. It may be located within the social/societal pillar of sustainability, i.e. be part of the 'p' that stands for people in the triple-p concept (PPP: people, planet, profit) (Shields and Orme-Evans, 2015, Appleby, 2005). Furthermore, in the triple-p concept, profit is also in the interest of people, and so is the planet, at least in as far as it concerns its inhabitability for humans (e.g. future generations). By contrast, it can be argued that the birds' interest should be recognised separately, e.g. by using 4 P's: PPPP, where the fourth 'p' stands for poultry. The Lisbon Treaty (Treaty of Lisbon, 2007) recognises that animals, including birds, are sentient. This implies that their welfare matters in and of itself, i.e., animals have intrinsic value.

When aiming for sustainability, therefore, we should be careful to avoid bias, i.e. we should not commit double (or even triple) counting of our own, i.e. human, interests. In fact, in response to the prevalent tendency to focus on economic sustainability, we propose that from a welfare perspective, what ultimately matters is OneWelfare, i.e. the welfare of people and animals combined. In any case, 'adopting the concept of OneWelfare could help to improve animal welfare and human well-being worldwide' (Pinillos et al., 2016). From this less biased, more universalised perspective, economic values should be regarded as secondary, or even tertiary, i.e. as a(n) (important) component of human welfare, where human welfare is in turn a component of animal welfare in the wide/inclusive sense as, from a biological point of view, we are (only one species of) animal too. This in fact leads to a reversal of the hierarchy of concepts that make up sustainability: rather than trying to figure out how animal welfare might be (a more natural) part of human-centred sustainability, the real, more conceptually, scientifically and morally correct logic of ultimate sustainability seems to be how its various components contribute to (the ultimate good/objective of overall/inclusive) animal welfare. A relevant concern from this OneWelfare point of view then is, for example, how to weigh the relative welfare interests of people and poultry. We will not try to answer this question here. We think it suffices to raise the question for the reader to contemplate further. (The interested reader may consider in this respect also the concept of a circular welfare economy (Bracke, 2017).

More sustainable broiler production is likely to accommodate a reduced number of birds. From an evolutionary perspective, chickens are currently the most successful terrestrial organism in that they are the most numerous. A 2017 estimate counts 22.8 billion chickens living on this planet (Statista, 2019). Such numbers may be taken to imply high levels of biological functioning, which has been regarded as a measure or even concept of welfare in itself (see Anonymous, 2001, Fraser et al., 1997). However, large numbers of poultry are also strongly related to the economic efficiency of fast growth in conventional housing and management systems, and not necessarily to welfare when defined subjectively, i.e. in terms of feelings, as the quality of life as perceived from the animal's point of view (Bracke et al., 1999).

Another, potentially relevant aspect to consider in relation to sustainability here is the ethical dimension. Welfare assessment *per se* is a factual question, which aims to describe the welfare state of an individual on a continuous scale from very good to very poor, as accurately as possible. Ethics, by contrast, concerns normative issues, i.e. what is morally acceptable. For ethical decision making the interests of all involved must be taken into account, and this may imply that, for example in the case of bird slaughter, it is not just the welfare of the birds that matters, but also the (sometimes very strong) feelings of people who are concerned about how animals are being slaughtered, whether they eat meat or not.

8.

A GOOD LIFE FOR BROILER CHICKENS: AN ANIMAL ADVOCACY PERSPECTIVE

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Eurogroup for Animals

Too often 'chicken' is still presented and marketed as a cheap and ubiquitously available commodity. This notion reinforces the disconnection – artificial, but convenient – between the 'product' and the living animal (Marino, 2017). Yet we now know that chickens, like other birds, have complex cognitive abilities, emotions, and sociality (Marino, 2017), so the way we treat them should reflect this knowledge.

When surveyed, **EU citizens recognise that broiler chickens are sentient and that they deserve to be treated better than they are now**. A 2019 survey of 7,000 EU citizens from seven countries revealed that 89% believe broiler chickens should be better protected; 82% believe it is important for chickens to enjoy their lives without suffering; 87% believe that it is important for broiler chickens to live in an environment where they can behave naturally; 85% think it is important for chickens to have access to an outdoor area (ComRes and Eurogroup for Animals, 2019). Such awareness needs to be fostered so that it can translate into a generalised willingness to act on their behalf. In particular, part of the work we will have to do as animal advocates is to ensure that empathy towards chickens also drives buying choices. In this way, chickens reared to higher welfare standards will become mainstream more quickly.

From the perspective of the animal advocacy movement, **the prerequisite in any type of animal farmin**g – for as long as animal farming continues to exist – **is the possibility for the animals to experience a good life**. This differs from the concept of 'life worth living' in that it includes an emphasis on positive experiences and positive affective states (FAWC, 2009). The concept of a 'good life' is constantly evolving and is far from being set in stone, also due to its many facets (Yeates, 2017) and because it is difficult to measure scientifically. However, the outcomes of the scientific contributions in this report strongly suggest that fast-growing broilers, by far the most numerous terrestrial animals farmed for meat worldwide, cannot have 'good lives' because their health and welfare are irreparably compromised by their genetics. Moreover, most rearing systems fail to offer these animals even basic opportunities to express important normal behaviours.

The market is sending positive signals concerning the uptake of higher-welfare breeds and rearing systems. Interest in slower-growing broiler chicken breeds is growing, at least in certain EU countries, thanks to initiatives spurred by animal welfare organisations and supported by consumers as well as by retailers, food businesses and farmers. In turn, genetic companies are working on widening the offer of slower-growing breeds to meet a growing demand for these animals. Science is taking a closer look at the links between better animal welfare and environmental sustainability. We warmly welcome these developments, which we hope will ultimately lead to an accelerated shift of the whole market towards better breeding and rearing practices.

As a movement, we will continue to promote and support market-driven initiatives aimed at improving chicken welfare. However, we believe that higher animal welfare standards should become the norm in the EU and that **EU legislation should be revised to include breeding objectives for slower growth and better health and welfare outcomes, to introduce animal welfare rules for broiler breeders and hatcheries, and to improve rearing conditions for all broiler chickens**. In 2018, the European Parliament called for a revision of the Broiler Directive that goes exactly in this direction. The Farm to Fork strategy, with its explicit inclusion of a revision of EU animal welfare legislation, represents a golden opportunity in this respect.

ANNEX

A.1
BROILER CHICKEN MARKET & TRADE INFORMATION

FRANCESCA PORTA
Eurogroup for Animals

Key messages

- EU broiler chicken production reached almost 7.4 billion heads in 2018
- In 2018 seven EU Member States held 62% of the EU market: France, Germany, Italy, the Netherlands, Poland, Spain and the United Kingdom
- Production costs (per kg carcass, 2017) are highest in the United Kingdom and France, and lowest in Poland
- From 2014-2018, Poland has grown its production by about 42% (in volume)
- In 2018, trade within the EU was 1,644,798 tonnes (imports) and 2,231,685 tonnes (exports)
- In 2018, the total EU export of chicken to non-EU countries was greater than import, with 725,806 tonnes exported and 130,500 tonnes imported
- From 2014-2018, the EU increased the total export of chicken to non-EU countries by 9.25% and increased import from non-EU countries with 37.0%
- The top three countries receiving EU chicken exports (in 2018) were: Hong Kong, China (11.1%), Saudi Arabia (9.5%), Ghana (9.3%)
- The top three countries exporting chicken to the EU (in 2018) were: Brazil (40.6%), Ukraine (38.3%), Thailand (7.7%)

The poultry meat sector is one of the most intensive farming systems in the EU. Intensive broiler chicken farming is characterised by high stocking densities, fast growth rates, very large holdings, and indoor rearing. This farming model accounts for more than 90% of broiler chicken production in the EU (EPRS, 2019). According to the European Commission (EPRS, 2019), farms with at least 5,000 broiler chickens are defined as commercial production. Although they account for 93.5% of all broiler chickens in the EU, they represent only 1% of all broiler chicken farms, while farms with more than 100,000 heads account for 38% of total broiler chickens in the EU (EPRS, 2019).

The data presented in this section covers the period 2014-2018.

A.2
DATA AND METHODOLOGY

The data reported and analysed in this Annex (unless referenced separately) has been extracted from Williams & Marshall Strategy (2019).

The methodology used by Williams & Marshall Strategy (2019) combines quantitative and qualitative analysis. An analysis of data retrieved from The World Bank, Eurostat, UN Comtrade Database, The European Central Bank, and websites of key EU broiler chickens farmers and main chicken meat producers was carried out. The collection of qualitative information was done through semi-structured interviews with market experts, such as representatives of the main market participants – manufacturers, distributors, wholesalers, retailers, importers, exporters, unions, professional associations and special publications. For this data collection 15 market experts have been interviewed – representatives of some of the main companies on the market[35].

The analysis of secondary information from official sources was used to verify the quantitative analysis and to enrich the qualitative one. Such information include data from industry portals and publications, trade associations, media agencies, articles and reviews, marketing agencies, commercial databases.

[35] The experts interviewed are representatives of the companies Favorit Geflügel AG, Plukon Food Group B.V., Moy Park Ltd., KScan Oyj, 2 Sisters Food Group Ltd., SOCIETA' AGRICOLA LA PELLEGRINA SPA, LOHMANN & Co. AG, Faccenda Foods Ltd./Avara Foods Holdings Ltd., Heidemark Mästerkreis GmbH & Co. KG, GALLIANCE VOLAILLE FRAÎCHE, Metro Cash and Carry, Schwarz Gruppe, Carrefour, REWE Group and Tesco Plc.

Williams & Marshall Strategy (2019) reported that in the international trade data-set, the term 'broilers' covers live domestic chickens. They can be divided in two groups: chickens that weigh less than 185g and chickens that weigh more than 185g. Most of these birds are imported for further raising and slaughtering for their meat, but a small number are kept by importing countries to produce eggs (broiler parent stock). All types of live broiler chickens in this Annex are referred to as 'live broiler chickens'.

A.3
THE EU BROILER CHICKEN MARKET

The EU broiler chicken sector registered an overall increase both in terms of production and consumption. In 2014, the EU raised 6.5 billion broiler chickens. Production reached almost 7.4 billion animals in 2018 (a 13.5% increase compared to 2014). Market analysis confirms expectations that in future years, growth will continue at a rate of about 1% to 3% annually.

The majority of broiler chicken meat production takes place in six EU Member States (France, Germany, Italy, the Netherlands, Poland, Spain) and the United Kingdom (see Figure 1). Together they hold almost 76% of total EU production (in heads) and this accounted for 62% of the EU market in terms of volume in 2018. The structure of the broiler chicken market in physical terms shows a very similar distribution.

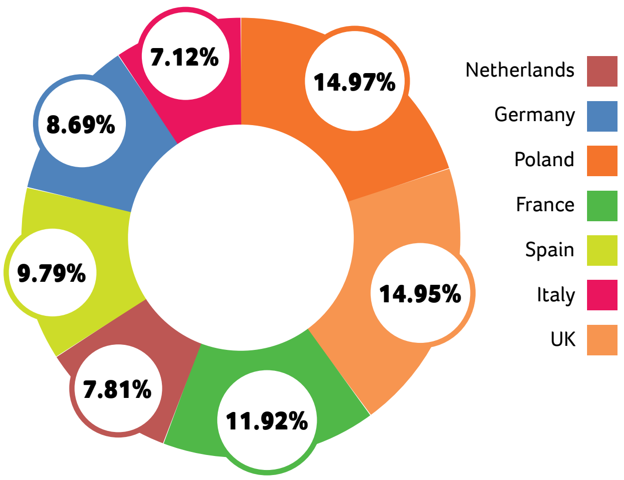

Figure 1 | Structure of broiler chicken farming in the EU main producing countries (% of total heads in 2018).

These countries have constantly increased their production in the period 2014-2018, especially Poland that has grown its production by about 42% (in volume of tonnes). In value terms, the largest producer in 2018 was the UK, due to the high producer prices of broiler chicken meat in this country. Overall, production costs (on farm and at slaughter) differ among the top producing countries listed above, with the highest level of production costs (per kg carcass) in the United Kingdom and France and lower production costs in Poland (See Figure 2) (Van Horne, 2018).

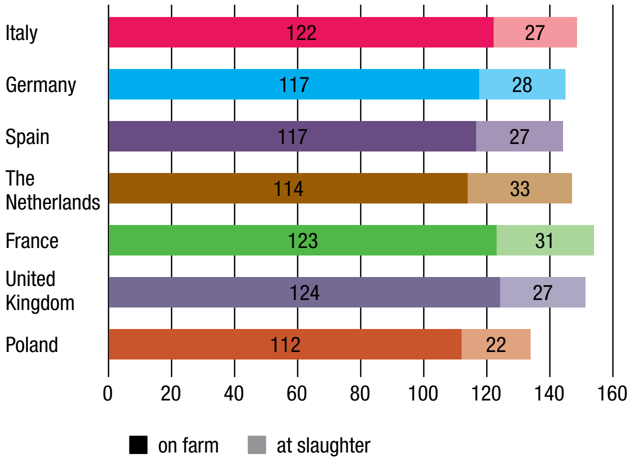

Figure 2 | Production costs (on farm and at slaughter) in top producing EU Member States (Euro cents/kg carcass weight, 2017 data). Source: Van Horne, 2018.

A.4
TRADE PERSPECTIVES

In addition to farming, the EU Member States are also trading live broiler chickens and chicken meat within the EU and with non-EU countries.

Intra-EU trade

Main players in terms of import are the Netherlands, Germany, Belgium, France and the United Kingdom, and for export are the Netherlands, Poland, Germany, Belgium and France. Figures for both export and import (Table 1 and 2) show that broiler chicken meat was traded more than live broiler chickens (Table 1 and 2), and it accounted for about 88% and 70% of total intra-EU export and import volume, respectively.

Table 1 | Structure of the EU export of broiler chicken meat and live broiler chickens to EU-28 countries (2014-2018).

Categories	Years	
	2014	2018
Broiler chicken meat* (in tonnes)	1,190,850	1,454,244
Live broiler chickens** (in tonnes)	146,324	190,554
Total broiler chicken (in tonnes)	1,337,174	1,644,798

Table 2 | Structure of the EU import of broiler chicken meat and live broiler chickens from the EU-28 countries (2014-2018).

Categories	Years	
	2014	2018
Broiler chicken meat* (in tonnes)	1,111,150	1,556,558
Live broiler chickens** (in tonnes)	549,456	675,100
Total broiler chicken (in tonnes)	1,660,606	2,231,658

* Includes frozen and fresh whole chickens, frozen and fresh chicken cuts (including edible fats and offal).

** Includes live chickens weighing less than 185g and live chickens weighing more than 185g.

Extra-EU trade

The extra-EU import and export of chicken meat and live broiler chickens is projected to increase. In 2018, export was much greater than import, with 725,806 tonnes exported (Table 3) and 130,500 tonnes imported (Table 4).

Over the past 4-year period (2014-2018), the EU has exported a growing volume of chicken to non-EU countries (see Table 3). The increase was due to the increase observed in the export of chicken meat, that has counter-balanced the decrease in the export of live chickens. Despite the fact that the EU is self-sufficient in terms of chicken meat production, it also imports chicken meat and live broiler chickens from non-EU countries. Between 2014 and 2018, this trade increased considerably, with an upsurge in the import of live broiler chicken by the EU from non-EU countries (Table 4).

In 2018, the major importers of EU broiler chicken (both meat and live animals) were: Hong Kong, and China, Saudi Arabia, Ghana, Switzerland, and South Africa. The same year, the EU imported broiler chicken (both meat and live animals) mainly from Brazil, Ukraine, Thailand, Chile, and the USA.

Table 3 | Structure of the import by non-EU countries of broiler chicken meat and live broiler chickens from the EU-28 (2014-2018).

Categories	Years	
	2014	2018
Broiler chicken meat* (in tonnes)	659,719	721,803
Live broiler chickens** (in tonnes)	4,614	4,003
Total broiler chicken (in tonnes)	664,333	725,806

Table 4 | Structure of the export by non-EU countries of broiler chicken meat and live broiler chickens to the EU-28 (2014-2018).

Categories	Years	
	2014	2018
Broiler chicken meat* (in tonnes)	93,395	127,267
Live broiler chickens** (in tonnes)	1,866	3,233
Total broiler chicken (in tonnes)	95,261	130,500

* Includes frozen and fresh whole chickens, frozen and fresh chicken cuts (including edible fats and offal).

** Includes live chickens weighing less than 185g and live chickens weighing more than 185g.

CONCLUSION

The general trend in the market and trade figures shows that the EU production of broiler chickens in the period reviewed, is increasing at all levels: production, imports and exports. This means that an increasing number of birds will be affected by the weakness of the current EU legislative framework concerning broiler chickens farming, transport and slaughter[36]. In particular, the expansion of the extra-EU trade in live broiler chickens and chicken meat translates into the entry into the EU market of animals, and animal-based products sourced from animals raised under standards that are likely to be lower than the minimum EU mandatory standards.

[36] See Section 1 : EU Legislation establishing minimum standards for the protection of broiler chicken welfare" of the present Report.

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