2.
BROILER CHICKEN WELFARE DURING PRE-SLAUGHTER TRANSPORT

LEONIE JACOBS
Department of Animal and Poultry Sciences, Virginia Tech, Blacksburg, VA, USA

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.

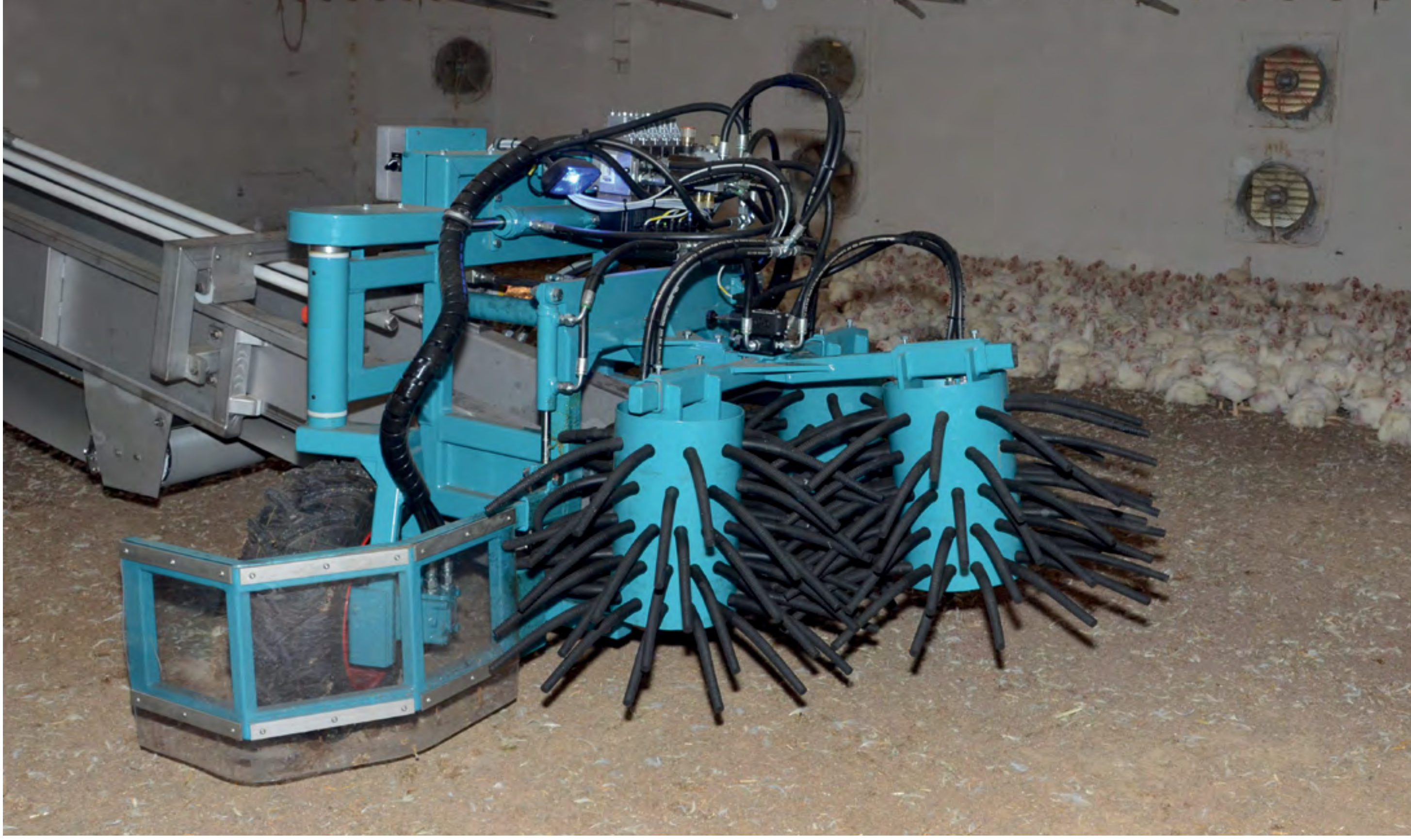

Figure 2.2 | **Chicken harvester – catching machine – with rotating rubber fingers to catch and lift birds from the litter floor. A conveyor belt moves the caught birds to the containers that are loaded onto the truck (photo courtesy of Peer System B.V.).**

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.

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