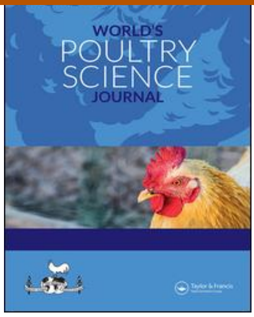

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Stakeholder perceptions on broiler chicken welfare during first-day processing and the pre-slaughter phase: a case study in Belgium

Evelien Lambrecht[a], Leonie Jacobs [b,c], Evelyne Delezie[b], Hans De Steur [a], Xavier Gellynck [a] and Frank Tuyttens [b]

[a]Department of Agricultural Economics, Ghent University, Ghent, Belgium; [b]Animal Sciences Unit, Institute for Agricultural and Fisheries Research, Melle, Belgium; [c]Department of Animal and Poultry Sciences, Virginia Tech, Blacksburg, United States

SUMMARY

Day of hatch and pre-slaughter processing are stressful events (involving selection, handling and transport) for broiler chickens, putting pressure on welfare, which has economic consequences. This case-study documented common industry practices and evaluated poultry industry stakeholder perceptions related to broiler welfare during day-of-hatch processing and the pre-slaughter phase. Twenty-three individual in-depth interviews were conducted with representatives of key stakeholders in the Flemish poultry sector: hatchery personnel (five), farmers (six), poultry catchers (two), transporters (three) and slaughterhouse personnel (seven). The findings showed various factors influencing broiler welfare during day of hatch processing and the pre-slaughter phase, with some discrepancies between stakeholder views and the scientific evidence. While stakeholders perceived the day of hatch processing procedures of chicks to be relatively under control, with no major issues, literature points out several issues, including first-week mortality and time without feed and water as major welfare problems. For broilers at slaughter age, the industry stakeholders' views aligned well with scientific evidence on major welfare issues, such as injuries, thermal stress, mortality during fasting, catching, loading, transportation and lairage. This study provides novel insights in stakeholder perceptions, and potential avenues for future research and actions to reduce animal welfare problems in the poultry sector.

KEYWORDS
Broiler; chick; welfare; slaughter; transport; industry

Introduction

Day-old chick post-hatch processing and transportation has received limited attention in relation to mortality and other aspects of their welfare (Jacobs *et al.*, 2016a). Nevertheless, transportation and early-life experiences are crucial for the performance of chicks during the entire production phase (Decuypere *et al.*, 2001; Mitchell and Kettlewell 2009). After the production phase (grow-out), birds are again transported. This pre-slaughter phase is

CONTACT Leonie Jacobs jacobs.leonie@gmail.com; jacobsL@vt.edu 175 West Campus Drive, Blacksburg, VA 24061, USA

a stressful event for broiler chickens, putting pressure on animal welfare with direct economic consequences. Poor transportation conditions cause stress, fear and injuries, which may result in poor meat quality and reduced slaughter yield (Aksit *et al.*, 2006; Petracci, Bianchi, and Cavani *et al.*, 2010), and diminishing efforts made by the farmer during the production phase and resulting in financial losses (EFSA 2011; Nijdam *et al.*, 2004). Welfare issues can occur during the transportation of both day-old chicks, from hatchery to farm, and slaughter-age chickens, from farm to the slaughterhouse.

Besides the negative impacts on animal welfare and industry profitability, broiler chicken transportation is visible to the public, and welfare violations can negatively affect the image of the poultry sector. Given that the general public recognises the need for welfare improvements for chickens (European Commission 2005a) and recognises that transportation could impair broiler welfare considerably (Hall and Sandilands 2007), stakeholders in the poultry industry are increasingly recognising the importance of welfare. There is a need for better understanding of adverse transportation effects, as scientific evidence varies in relation to identified risk factors and welfare outcomes (e.g. Chauvin *et al.*, 2011; Nijdam *et al.*, 2004; Vecerek *et al.*, 2006, 2016). For instance, average commercial pre-slaughter mortality prevalence in these studies varied from 0.18% to 0.46%, with comparable and different risk factors identified.

The following case-study documented common poultry industry practices of day-old chicks and broilers at slaughter age and evaluated stakeholder perceptions of welfare issues during the pre-slaughter phase. The Belgian poultry sector was used as a case for conducting interviews with industry stakeholders ($n = 23$). The interviews were based on site visits to hatcheries ($n = 5$), farms ($n = 6$), poultry catcher firms ($n = 2$), transportation firms ($n = 3$; including a single firm specialising in transportation, and two slaughterhouses with their own fleet) and slaughterhouses ($n = 7$). The stakeholder perceptions were complemented with findings from scientific research and legislative documents. Here, the focus was evidence of welfare impacts associated with first-day processing and the pre-slaughter phase of broiler chickens, as well as awareness gaps of involved stakeholders.

Interviews

To study poultry industry stakeholder perceptions and common strategies related to broiler welfare, individual representatives of different stakeholders in the poultry chain (from hatcheries to slaughterhouses) were interviewed, in line with the approach of Palcynski *et al.* (2016). This qualitative research method consisted of a face-to-face interview between a single respondent and two interviewers. In contrast to focus groups, this method ensured the exchange of information without social pressure, e.g. from similar or different actors in the supply chain, and revealed underlying and important attitudinal information (Flick 2018; Stokes and Bergin 2006). When visiting the site, the real situation was ascertained, which is not always the case when using surveys. Hence the applied method was considered appropriate to gather insights from stakeholders involved in day of hatch processing of chicks and the pre-slaughter phase of broilers.

An interview guide was developed based on consultations with key industry and academic experts. Pilot testing was performed prior to the actual interviews, in order to improve the content and structure of the topic guide. The final guide consisted of a list of open questions related to common practices and welfare concerns. The interview guide was based on a semi-structured format (topic list), by which the direction and depth of the issues were determined by the interviewee's initial answers (Powell and Single 1996). This allowed for discussion with the interviewee, rather than a straightforward question and answer format.

All respondents were first contacted by telephone to introduce the aim of the study and to arrange an appointment for the interview. The interviews were conducted at the respondents' place of work and took, on average, 1 h. All interviews were undertaken by the same two interviewers. In the majority of the cases, the interviews were followed by a site visit, where pictures and notes were taken to facilitate the analysis. The site visits allowed the interviewers to add remarks, and visualise common practices, which further supported the data. Welfare aspects and common practices were analysed from interviews until no additional data was found, meaning that new data (welfare concerns and common practices related to transportation) tended to be the same as data already collected during interviews, in line with previous qualitative research on broiler welfare (Palcynski *et al.*, 2016). At that point, no additional interviews were conducted, with the assumption that additional interviews would not provide new information, and data were compiled for analysis.

A case-study approach was used in order to provide an in-depth understanding of (perceived) welfare impacts during the pre-slaughter phase of broilers. Data from the interviews were manually transcribed and categorised based on thematic coding. Descriptive content analysis was applied in order to summarise stakeholder experiences about welfare impacts at the different stages of production, both for day-old chicks (first-day processing: hatching and processing, holding, loading and transporting) and slaughter-age broilers (pre-slaughter phase: before catching, catching, crating, loading and transporting, lairage). A narrative analysis approach was used to describe the stakeholder perceptions of welfare issues.

Participants

In total, 23 in-depth interviews were conducted with stakeholders active in the Flemish broiler chicken sector. Table 1 provides an overview of the interviews per type of stakeholder. Five stakeholder types were targeted: hatchery personnel, farmers, poultry catchers, transporters and slaughterhouse personnel. The common practices during the first-day processing, and its potential impacts on welfare, were evaluated through interviews during guided on-site visits in five hatcheries and six farms. In hatcheries, employees responsible for transportation were selected as interviewees. Information on current

Table 1. Characteristics of the interviewed stakeholders: type of stakeholder, number of visited production units where interviews were held, and estimated broiler chicken market coverage.

Type of stakeholder	Number of visited production units	Estimated market coverage
Hatcheries	5	>50% of Belgian broilers hatched
Farmers	6	~1% of Belgian broiler growers
Catcher firms	2	~15% of the certified chicken catchers
Transportation firms	3[a]	>50% of Belgian broilers transported
Slaughterhouses	7	>60% of Belgian broilers slaughtered

[a]Two of the transportation firms were slaughterhouses with their own fleet.

commercial practices associated with the pre-slaughter phase (from farm to slaughter) and its welfare impact was based on guided on-site visits of seven slaughterhouses, followed by an interview with the employees responsible for planning of arrival of birds. Regarding the transporters, two slaughterhouses with their own transportation units and a major transportation firm participated. The two catching firms that took part in this study accounted for approximately 15% of the certified chicken catchers. The six farmers that were interviewed about day-old chicks, were also questioned about chickens at slaughter age.

Although representativeness was not considered an objective in this qualitative research, the sample in this study was organised in such a way that, for most stakeholders (hatcheries, transporters and slaughterhouses), at least 50% of the market of Belgian broilers was represented by the participating respondents.

Survey findings

The first day of life of broiler chicks

Figure 1 depicts the different stages associated with the first-day processing of day-old chicks, and the key aspects linked to potential welfare impacts, as perceived by stakeholders in the interviews and as reported in scientific literature. The hatchery is responsible for hatching and processing, holding, loading and transportation of the chicks. Hence, the hatchery ought to be responsible for the quality and welfare of the chicks that are delivered to the farm. Some hatcheries own the parent flocks, adding to their responsibility of delivering good-quality chicks and ensuring welfare of the broiler breeders.

Hatch and processing

The hatchery personnel identified risks for chick welfare related to hatch and processing. They mentioned fasting or time without feed, injuries due to processing and stocking density in crates as potential welfare issues.

From hatch until arrival at the farm, birds generally do not have access to feed or water. To limit post-hatch time without feed, hatchery staff aim to minimise the time window between first- and last-hatched chicks. Interviewees stated that eggs from the

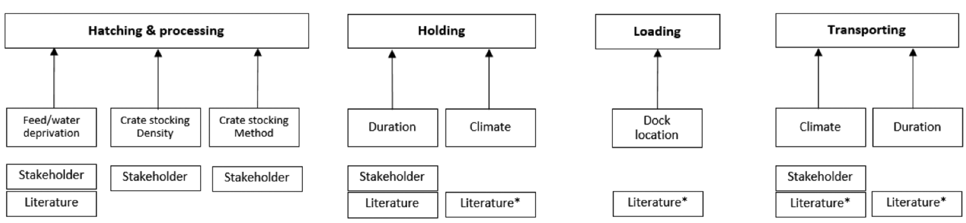

Figure 1. The first-day processing and transportation of day-old chicks and factors of potential welfare impacts. Note: 'Stakeholder': factor perceived by stakeholders as a potential welfare issue, based on their practices. 'Literature': factor demonstrated to have an impact on broiler welfare according to evidence reported in scientific studies. *Scientific evidence referring to this factor mainly looked at extreme conditions, which were not present in the current practices (hence, not mentioned by stakeholders), e.g. temperature-controlled truck.

same parental flock and laying date are usually placed in the same incubator. Reported time windows varied substantially, from 5 h, up to 12 or 24 h. Negative impacts of feed and water deprivation during hatching have been well described (for an overview, see De Jong *et al.* 2016b). According to Wang *et al.* (2014), there is a time window of 24–48 h between the first- and last-hatched chicks, with variations depending on the eggs (e.g. size) and parental flocks (e.g. age). Therefore, the so-called 'day-old chicks' can be actually up to 3-day old when they are transported (Jacobs *et al.*, 2016a; Jacobs *et al.* 2017). By using yolk sac reserves, chicks are expected to survive 72 h (3 days) after hatching. However, it is assumed that modern genetic lines may deplete their reserves more quickly, due to the higher metabolic rates associated with faster growth (EFSA 2011). Furthermore, when chicks are fasted, the use of yolk reserves is reduced (Vieira 1999), the gastrointestinal system is stunted (Dibner 1999) and intestinal growth is hampered (Bigot *et al.*, 2003). Because transportation may exacerbate the depletion of reserves through excessive thermoregulatory demands and stress, the relation between yolk sac reserve depletion and transportation should be examined to determine the impact of transportation on chick welfare and productivity (EFSA 2011).

A potential solution could be the provision of feed and water in the hatchery immediately after hatching, which has been studied and commercially applied in some hatcheries, but none of the interviewed hatcheries. When chicks were fed immediately after hatch, an increase in chick weight, yolk free body mass, heart weight, liver weight and intestine length was found compared to chicks that had not been fed until their arrival at the farm (Molenaar *et al.*, 2011). A positive relationship between time without feed and weight loss was found, where chicks showed increased relative growth up to 7 days when they had immediate access to feed compared to those with delayed access (Careghi *et al.*, 2005). Conversely, early-hatched chicks (fasted at least 7 h longer) were heavier than late-hatched chicks from day 1 up until day 9 of age, possibly due to late hatchers being of lower quality (Bergoug *et al.*, 2015). A more advanced alternative to immediate feeding at the hatchery is to transport incubated eggs, which is currently being explored (one2Born, Nistelrode, the Netherlands or X-treck, V.O.F. Wingens, Schaijk, the Netherlands). Few studies have investigated the welfare impacts, but, so far, outcomes were similar for production parameters and improved for an animal welfare parameters (e.g. footpad dermatitis) compared to conventional hatching (de Jong et al., 2016a, 2019).

In a conventional system, hatched chicks are removed from the incubator and selected for transport. Chicks are visually assessed for quality by hatchery personnel, followed by bird counting (automatically or manually) and immunisation with a coarse vaccination spray (newcastle disease, infectious bronchitis or a combination; Cserep 2008). Interviewees indicated that this spray leads to a decrease in body temperature, but the effect on bird welfare was reported as unknown. No scientific literature has reported the impact of the administration spray vaccines on immediate welfare, such as thermal discomfort.

Hatcheries make use of plastic transportation crates with a standard size of 60 × 40 × 12 cm, containing 90 chickens under normal circumstances, which equals a space availability of 26.7 cm^2 per chick. Chicks are crated manually or mechanically. One hatchery interviewee mentioned leg injuries as a welfare concern, possibly due to inappropriate loading or stacking of crates. However, the respondent stated this hardly ever occurred. Guidelines in the United States recognise that injuries are a welfare concern during chick processing, and it is mentioned that they can be avoided by proper design of chick-processing systems (National Chicken Council 2017). However, scientific data are lacking.

The interviewees identified crate stocking density as a risk factor for bird welfare, with thermal stress being a potential animal response during holding and transportation. During warm weather, responsible personnel often reduce the number of chicks per crate to a maximum of 80. This number could be increased to a maximum of 100 chicks per crate during extreme cold weather or in case of smaller chicks (i.e. from young parental flocks). In commercial practice, the stocking density depends on the perceived risk of thermal stress in subsequent stages, based on past experiences. Respondents stated that they monitored panting (gasping) as an indicator of heat stress and cold feet as an indicator of cold stress. To the authors knowledge, no studies have specified stocking densities for day-old chicks during holding and transportation, although it is a recognised factor in relation to ambient temperature and humidity (Mitchell 2009).

Interviewees regarded hatchery processing as having some welfare risks, with prolonged time without feed, potential injuries and crate stocking density mentioned. The stress related to hatching and processing was generally considered to be minimal. Yet, a recent study on laying hens reported that the complete processing at a commercial hatchery, including crating, resulted in an increased acute stress response (measured by corticosterone levels) compared to control birds that were not processed (conveying, sex sorting vaccination, crating; Hedlund *et al*., 2019).

Holding

After birds are placed in crates, the crates are stacked on carts, leaving space in between the two stacks for ventilation. The stacked crates are then placed in a holding room until the truck can be loaded. Temperature in these holding rooms is controlled, and ranged between 20°C and 25°C, according to respondents.

Among the visited hatcheries, differences were observed in holding times. Some hatcheries aimed to avoid holding time, while for others it was standard procedure to process all day-old chicks in the early morning and transport them later on in the day, which led to waiting times of up to 6 h. According to the representatives of the latter hatcheries, the influence of such prolonged waiting times on chick welfare was minimal, as they believed adequate energy and water reserves were provided from the yolk sac. One respondent reported that it would be better to deny chicks access to water and feed for a couple of hours in order to decrease the risk of yolk sac inflammation. However, the opposite has been argued, where there are benefits from early access to feed, including improved intestinal growth and nutrient intake (Sklan 2001). Besides the impact on fasting, holding prior to transportation was not mentioned as a welfare concern. Extended holding of fasted chicks for 50 h in transport crates showed that a low holding temperature of 20°C was associated with increased mortality rate compared to higher temperatures of 25–35°C (Xin and Harmon 1996). This experimental treatment did not mimic commercial practice (holding was studied after processing and transport); however, it did illustrate the impact of temperature during holding for crated chicks on mortality, which is a welfare concern (Xin and Harmon 1996). Future research needs to focus on separate aspects of hatchery processing and holding to elucidate the effects on welfare.

Loading and transportation

In two hatcheries, the chicks were loaded on a truck *via* a loading quay, while for the other three hatcheries the crated chicks had to be loaded outside, and hence were briefly exposed to weather conditions. Whereas respondents shared the view that day-old chicks should not be exposed to extremely cold weather conditions (e.g. cold, windy and/or rain), they expected marginal impacts on animal welfare, given the short duration of exposure. One review has discussed the impact of temperature on day-old chicks, but exposure time was hours rather than minutes (Bergoug *et al.*, 2013).

The hatchery respondents stated that each hatchery was responsible for the development of their own trucks, together with an engineer. One hatchery used trucks with natural ventilation for transportation over small distances. However, in all other hatcheries, trucks were temperature-controlled, with air supply in the bottom of the truck and vents in the ceiling.

One hatchery respondent did not perceive transportation to affect welfare or production of the birds. Three hatchery respondents indicated that welfare issues were uncommon, with mortality as the main indicator for welfare during transportation. Respondents did recognise the importance of a controlled thermal climate during transportation. Before actual transportation commenced, interviewees stated that trucks were preheated, up to a temperature of 25–27°C, which was maintained during transportation. The driver could monitor and adjust the temperature in the cabin, which was expected to limit the impacts on welfare. In literature, adverse impacts have been reported under different, extreme conditions. High temperature (40°C compared to 34°C) during post-hatch transport for 4 h, for example, was associated with more frequent occurrence of crooked toes and twisted legs and poor gait at 41 days of age, indicating that transportation temperature can affect birds until slaughter age (Oviedo-Rondón *et al.*, 2009). A review has determined thermal load during transportation as a risk for chick welfare (EFSA 2011). Unsuitable thermal conditions during transportation may result in hypo- or hyperthermia. An optimal temperature-humidity range of 24.5–25.0°C and 63–60%RH were identified for chick transportation, based on measurements of body temperature, metabolic rate, body weight loss and plasma metabolite levels (reviewed by Mitchell 2009). These temperatures were comparable to applied temperature control reported by the interviewees.

Chick transportation reportedly takes on average 1.5 h, but can last up to 11 h. This wide deviation in duration is caused by the use of a single truck for different farms, with long durations for chicks that are transported to the last farm. Nevertheless, respondents perceived that transportation time has a negligible influence on welfare, with mortality at arrival or during the first week on-farm being an indicator for bird welfare. According to respondents from both hatcheries and farms, first-week mortality ranged between 0.5% and 1% under normal circumstances. This aligned well with scientific evidence. Chou, Jiang, and Hung *et al.* (2004), for example, suggested that transporting for a long duration and distance (i.e. over 50 km on mountain roads) resulted in elevated mortality rates (1.4% versus 1.2%) during the first week of the grow-out period. Bergoug *et al.* (2013) did not find a relationship between mortality and transportation duration (0, 4 and 10 h) in France. Similarly, Jacobs *et al.* (2016a, 2017) did not obtain evidence that transportation duration for day-old chicks needed to be reduced, based on their investigation of stress response, welfare, physiology and productivity under Belgian conditions.

Besides mortality, other welfare or health aspects could be affected by transportation. Weight gain was impaired during the first weeks of grow out in case of a longer interval between hatching and housing, although it did not affect final weight or feed efficiency (Baião *et al.*, 1998; Batal and Parsons 2002; Bergoug *et al.*, 2015; Fairchild *et al.*, 2006). Chicks transported for 11 h compared to 1.5 h lost more body weight, and not all body weight loss was due to yolk sac weight loss (Jacobs *et al.*, 2016a). It should be noted, however, that the impact of the transportation process itself is difficult to separate from influencing factors related to pre-incubation, incubation, hatching and post-hatching.

The pre-slaughter phase of broiler chickens

In Belgium, thinning is common practice, where about 6,000 birds are caught at around 35 days of age (Tuyttens *et al.*, 2014). This allows producers to increase the number of birds produced per production round, while maintaining compliance with stocking density legislation (expressed in max kg/m^2) (European Union 2007). A week later at about 41 days of age, all remaining broilers are caught, loaded, transported and slaughtered. Figure 2 provides an overview of the pre-slaughter phase of broiler chickens, and the various aspects that were linked to potential welfare impacts, by stakeholders and/or in scientific literature.

Before catching

Commonly, 8 h before catching, farmers stop the feed provision to reduce intestinal content at slaughter and avoid faecal contamination during the slaughter process. Minutes before catching, they also remove the water lines. The legislation for animals that undergo transportation (EU Council Regulation 1/2005) stipulates a maximum duration of 12 h for birds without water or feed (European Commission 2005b). However, it only regards transportation duration, disregarding the stages before or after transportation: 'For poultry [. . .] suitable food and water shall be available in adequate quantities, save in the case of a journey lasting less than [. . .] 12 hours disregarding loading and unloading time'. Interviewees were unaware of the specific legislation regarding deprivation of feed (EU Council Regulation 853/2004; European Commission 2004), which was reflected in their different interpretations of feed withdrawal and fasting. Some farmers and a transportation firm employee mentioned an increase in mortality when chickens were deprived from feed

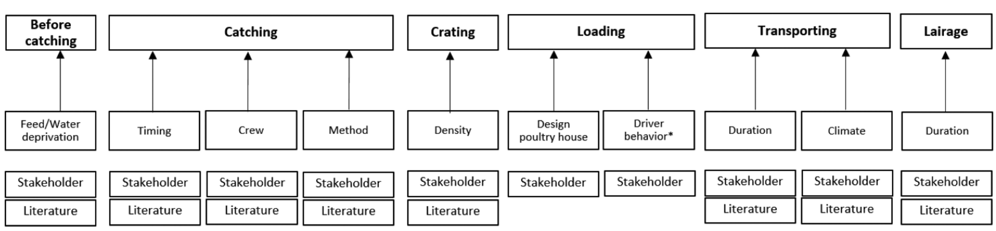

Figure 2. The pre-slaughter phase of chickens and factors of potential welfare impacts. Note: 'Stakeholder': factor perceived by stakeholders as a potential welfare issue, based on their practices. 'Literature': factor demonstrated to have an impact on broiler welfare according to evidence reported in scientific studies. **also for transportation and lairage.*

for approximately 8 h before catching compared to shorter deprivation times. This was especially the case when both transportation and lairage were prolonged, in combination with low ambient temperatures. When taking into account loading and lairage, time without feed can be up to 24 h in Belgium (Jacobs *et al*., 2016b), leading to reduced body weight, hunger and frustration. Most body weight loss was observed after being fasted for more than 13 h (Delezie *et al*., 2006). Fasting for 10 h resulted in a stronger stress response compared to transported birds that were not fasted (Nijdam *et al*., 2005). Also Kannan and Mench (1996) found that feed-deprived broilers showed increased plasma corticosterone levels, associated with acute and chronic stress. Given that longer withdrawal periods (>12 h) are associated with higher incidence of faecal and bile contamination (Delezie *et al*., 2006), feed withdrawal periods of 4–5 h prior to catching are recommended (Delezie 2006). As such, the commonly applied duration of feed deprivation (about 8 h) exceeds the evidence-based recommendation.

Catching

Most farmers preferred catching, as well as loading, at night. Catching often took place between 8.00pm and 7.00am. In their opinion, the advantages of catching during the night are that birds remain calmer, it is easier to find people to help, there is less traffic on the road and it is more convenient to combine with other agricultural activities during daytime. Night-time catching, thus night-time transportation, was associated with lower dead on arrival (DOA) rates compared to morning or daytime transports (Nijdam *et al*., 2004).

Stakeholders agree that catching crew and method can affect bird welfare. Regarding the former, broilers are predominately caught manually by professional catching crews, even though alternatively, friends, family or acquaintances are involved. Previous studies showed the effect of catching crew on DOA rates (Chauvin *et al*., 2011; Ekstrand 1998; Nijdam *et al*., 2004), although a more recent Belgian study did not reveal any differences in welfare impact based on the type of catcher (Jacobs et al., 2016b). Fractures and dislocations in broilers have been associated with catching as well as with handling at the slaughterhouse (EFSA 2011; Kittelsen *et al*., 2015). Nijdam *et al.* (2006), for example, studied causes of death between catching and slaughter and found that almost 30% of birds with macroscopic lesions (89% of DOA birds) were due to trauma. Furthermore, associations between catching and bruising prevalence have been found (Delezie *et al*., 2006b; Ekstrand 1998).

Two methods of catching were applied in Flanders, mechanical and manual catching. In case of manual catching, the birds are picked up by their legs, held inverted and carried with three to four birds in each hand to be loaded into transportation containers. A minority of flocks (around 25%) are caught mechanically. The mechanical harvesters pick up birds, and birds are placed in the container with a conveyor belt, without being manually handled or carried inverted (Bayliss and Hinton 1990). Among the respondents, opinions differed about the use of both methods and their impact on broiler welfare. Based on their observations, mechanical catching seemed to show a more constant level of roughness with which the chickens are caught, compared to manual catching, which solely depends on the people involved. Farmers that choose mechanical catching reported fewer fractures and carcase rejections compared to manual catching. Scientific evidence has linked DOA rates to the applied catching method (Chauvin *et al*., 2011; Ekstrand 1998; Nijdam *et al*., 2004). A Dutch study found that both mechanical and manual catching were equally stressful based on corticosterone levels (Nijdam *et al*., 2005), and an older study reported more bruising in mechanically caught birds, compared to manually caught birds (0.04% *vs.* 0.02%) (Ekstrand 1998), potentially because a different harvester was used (Jacobs 2016). Most studies lend support for the most studies lend support for mechanical catching mechanical catching, in line with the stakeholders' views. In Belgium, for example, fewer bruises on wings were found when birds were caught mechanically (4.2% *vs.* 7.7%), although no differences were found for bruises on breasts and legs (Delezie *et al.*, 2006b). Similarly, Knierim and Gocke (2003) observed fewer bruises (2.0% *vs.* 3.0%), fractures (0.7% *vs.* 0.9%) and dislocations (0.5% *vs.* 0.6%) in mechanically caught flocks. Nevertheless, in practice, most farmers prefer manual catching over mechanical as they perceive it as being faster and they avoid the risk of any defects of the machine.

Crating

Slaughterhouse personnel, farmers and the transportation firm employees mentioned high crate stocking densities as an important issue for animal welfare, regardless of the catching method. High stocking densities have been also identified as a major stressor in scientific literature, with a positive relationship between crate stocking density and mortality found in France, Hungary, the Netherlands, Germany and Canada (Chauvin *et al.*, 2011; Kopecsnik 2008; Nijdam *et al.*, 2004; Whiting *et al.*, 2007). A Belgian study by Jacobs *et al* (2016b), however, did not find a relationship. Farmers in our case study experienced that high stocking density can lead to heat stress and increased mortality, especially during warm days. Both cold stress, as shown in Canada (Burlinguette *et al.*, 2012; Knezacek *et al.*, 2010) and heat stress for broilers in crates, as shown in the United Kingdom and the United States (Bayliss and Hinton 1990; Ritz *et al.*, 2005), are considered welfare impairments, possibly leading to an increased DOA.

In general, interviewed planners strived to stay below the maximum legal density allowed. The EU Council Regulation 1/2005 (European Commission 2005b) stipulates maximum transport crate stocking densities of 160 cm^2 per kg live weight for broilers at slaughter weight. If the density exceeded this maximum density by 10%, the Federal Agency for Food Security could reprimand the transporters. Among the interviewees, three reasons were put forward for having an excessive number of birds per crate. Firstly, the transporter, and in some cases the slaughter plant, determines the number of chickens per container based on the estimated bird weight, as communicated by the farmer. According to slaughterhouse respondents, farmers often underestimate these body weights. They further believed that farmers may do this to delay the slaughter date, as it results in heavier birds and thus a higher farm income. Furthermore, slaughterhouse personnel state they clearly communicate the maximum acceptable weight per bird, while they experience that farmers often exceed this. Secondly, farmers and transportation planners said stocking density requirements are exceeded to avoid the need for an additional truck to transport only a few broilers. In order to save costs, remaining broilers are distributed among other trucks. Thirdly, the drawers or crates are filled by different people at the same time, which could result in inconsistencies with bird counting. According to farmers and transporters, this could be avoided by assigning one coordinator per container for counting, as was also shown at one of the farms. This person could also be responsible for ensuring in-crate welfare, by preventing chickens to be placed supine in crate, and preventing that birds get stuck, with the latter observed in 0.21% of the birds crated for commercial transports (Jacobs *et al.*, 2016b). Interviewees reported that supine birds in crate have a minimal chance of survival during transportation, and acknowledged the importance of upright placement for animal welfare. In line with the perceptions, a strong positive association was found between prevalence of birds supine in crate and DOA rate (Jacobs *et al*., 2016b).

Loading and transportation

Once the containers are filled, they are loaded on trucks, either by the farmer or by the catching firm using a forklift. Interviewed farmers mentioned differences in the drivers' roughness of lifting or moving the container, and acknowledged possible impact on broiler welfare during loading, transporting as well as lairing (3.2.5). In line, impact of driving styles has been suggested as a risk factor for in-transit welfare (Grandin 2001; Nielsen, Dybkjær, and Herskin *et al*., 2011), but possibly not specifically studied. Slaughterhouse interviewees, for instance, indicated that they observed different DOA rates and carcase rejections depending on the driver. Yet, the driver is not the only factor impacting welfare during loading. In one farm visit, a poorly designed poultry house entrance was observed, resulting in full containers occasionally being dropped when loaders drove from the house to the truck. No studies have specifically focused on this aspect of broiler transportation.

The trucks used for transport are specially designed for poultry transport, and are not actively ventilated, although some trucks have passive ventilation through openings in the roof or sides. Transporters use integrated side curtains to protect birds from adverse cold or wet conditions, which are closed when ambient temperature falls below 10°C according to respondents. Transporters considered the 'driving' aspect of transportation on bird welfare to be minimal, though not all respondents agreed, especially when it relates to curtain use. If a truck is stationary, drivers should open at least one curtain to ensure ventilation and reduce the risk of heat stress. Many studies have identified ambient temperature, microclimate and thermal stress as a major welfare concerns during transportation of broilers, inducing physiological stress (Kettlewell *et al*., 1993). Thermal stress is determined to be one of three major causes for DOAs, together with health status of the flock, and physical injury (Bayliss and Hinton 1990). Handling and transport under cold ambient conditions (−5 to 5°C) induced a stronger stress response compared to under warmer conditions (10–35°C) (Vošmerová *et al*., 2010). In a study in the Czech Republic, the greatest mortality rates were observed during winter months, while the lowest mortality rates were found in summer months in Czech Republic (Vecerek *et al*., 2016). In Canada, 3- to 4-h transportation at temperatures below 0°C decreased internal body temperatures in broiler chickens to 39.7°C versus 40.2°C and higher (Dadgar *et al*., 2010). The adverse impact of heat stress has been well-studied (reviewed by Mitchell and Kettlewell 2009). This was particularly the case when maximum ambient temperatures were above 17°C, which was considered the critical maximum daily temperature after which mortality rates increased significantly (Warriss, Pagazaurtundua, and Brown *et al*., 2005). A positive association between cloacal body temperature, panting and DOA rates indicates a link between heat stress and mortality (Jacobs *et al*., 2016b). Furthermore, increased mortality was related to elevated temperatures during loading and at lairage at the slaughterhouse, rather than on a moving vehicle (Ritz, Webster, and Czarick *et al*., 2005).

According to slaughterhouse personnel, longer transportation seemed to be disadvantageous for bird welfare, especially during extreme warm or cold days, which is reflected in an increased DOA prevalence. The majority of Belgian transports take on average about 2 h, with a range between 30 min and 5 h, as derived from 81 commercial transports (Jacobs *et al*., 2017). Indeed, transportation duration, in combination with ambient temperature and prolonged lairage has been considered as a key predictor for DOA prevalence (Nijdam *et al*., 2004), something which was also noted by the stakeholders. Other studies confirmed the impact of prolonged transportation on DOA, such as a duration beyond 9 h or distances over 300 km (Vecerek *et al*., 2006; Warriss, Pagazaurtundua, and Brown *et al*., 2005).

Lairage

Upon arrival at the slaughterhouse, the birds are laired. According to slaughterhouse respondents, birds need to recover from transportation, and lairage leads to better meat quality. Thus, they perceive short lairage as a positive factor for bird welfare. However, the interviews and visits demonstrated a large variability in lairage conditions and difficulties avoiding extended lairage times.

Depending on the slaughterhouse, containers are stacked inside a warehouse, or outside, partially covered or still on the trailer. Lighting regimes (natural, darkened or blue) and ventilation differ depending on the slaughterhouse and, for ventilation, the personnel. In addition, a water spray or mist is sometimes used to cool the birds on warm days. Literature as well as stakeholders recognise the negative impact of both prolonged transportation and lairage duration on DOA% (Nijdam *et al*., 2004). Studies indicate that prolonged lairage posed a risk for mortality (Chauvin *et al*., 2011; Nijdam *et al*., 2004). Chauvin *et al*. (2011) showed a greater risk for DOA when lairage takes over 260 min, Nijdam *et al*. (2004) modelled the risk for DOA to increase with every 15 min lairage duration increase (odds ratio 1.03).

Slaughter and inspection

Slaughterhouse respondents emphasised the complexity of the slaughter logistics. While they aim to slaughter birds in order of arrival, birds with high slaughter weights or stocked at high density are often prioritised to avoid increased mortality (due to heat stress). *Salmonella ssp*. status also plays a role in planning, as *Salmonella spp*.-positive chickens should be slaughtered last. Slaughterhouse personnel consider the latter when scheduling transportation, so that those birds are collected last, although this is often difficult to organise. Furthermore, some farmers preferred to catch their chickens in the evening rather than at night or in the morning, irrespective of moment of slaughter, which leads to long wait times at the slaughterhouse. The complexity (Ljungberg *et al*., 2007) and importance of logistics at the slaughter plant in relation to welfare were recognised in literature (Cockram and Dulal 2018). In the latter review, the authors argue to process birds as soon as they arrive at the plant, which conflicts with current commercial methods, where lairage ranges from 15 min to 9 h.

After lairage, depending on the type of containers used, the birds are either tipped over automatically so the birds drop on a conveyor belt or the crates are removed from the container and placed onto a conveyor belt, where birds are manually picked and shackled. Fractures were observed at two Norwegian slaughterhouses resulting from pre-slaughter handling, more so than compared to during catching and loading on-farm (2.4% *vs.* 0.8%) (Kittelsen *et al.*, 2015).

On the conveyor, DOA birds are removed from the flock and recorded. Respondents stated that when the pre-determined percentage of slaughterhouse rejection rates (mostly between 0.5% and 1.5%) is exceeded, the farmer is financially penalised. The fees are determined by the slaughterhouse personnel and are included in the contract with the farmer.

Key findings and recommendations

This study aimed to document common poultry industry practices of day-old chicks and broilers at slaughter age and evaluate stakeholder perceptions of welfare issues during the pre-slaughter phase, by targeting the Belgian poultry sector. Based on on-site visits and in-depth interviews, the findings indicate varying degrees of broiler welfare impacts, from hatching to slaughter, for which different parties are responsible.

The interviews and visits revealed discrepancies between stakeholders, with responsibilities being shifted to one another, without recognising their own potential impact on bird welfare. For example, while farmers stated that the responsibility for broiler welfare lies with the transporter as soon as the birds leave the premises, transporters and slaughter plant personnel consider catchers responsible for major welfare issues, indicating that, in their opinion, transportation in itself does not pose risks to bird welfare. In commercial practice, slaughter plant personnel held the farmer responsible for broiler welfare, as the latter receives financial penalties when certain thresholds of DOAs and rejections are exceeded. However, the majority of farmer, transporter and slaughter plant respondents did recognise the overall impact of the pre-slaughter phase on broiler welfare, but also felt incapable to make changes.

Regarding day-old chicks, interviewees consider the welfare impacts to be limited, given that the transportation process is considered to be relatively well controlled. First-week mortality was reported to be between 0.5% and 1%, and transportation was not perceived as a risk factor for mortality. They mainly associate potential welfare impacts for day-old chicks with duration of and feed and water deprivation, duration of holding and climate conditions during transport, in line with scientific literature. Stakeholders also refer to factors related to crating (stocking density, stocking method), while researchers additionally considered holding conditions, the loading dock location and transportation duration as potential factors. Furthermore, it is important to note the discrepancy in the potential role of water and feed, where the benefits of early access provision in literature (Sklan 2001) were countered by stakeholders as they pointed to the risk of yolk sac inflammation. This highlights an educational need to improve the understanding of risks associated with water and feed deprivation.

Regarding broilers at slaughter age, industry stakeholder views are in line with scientific evidence on the occurrence of welfare risks before catching (duration of feed/water deprivation), catching (timing, crew and type of method), crating (density), transporting and lairage (duration and climate), slaughter (waiting time). However, stakeholders also emphasised potential impacts from the poultry house design, or driving behaviour (during loading, transportation, lairage).

Discrepancies between stakeholder groups were mainly oriented towards the responsibilities of ensuring broiler welfare, while there was only limited disagreement on welfare risk factors within stakeholder groups. Regarding the latter, it appears that the large differences in the practices (e.g. time window of hatching, holding times) did not lead to substantial differences in perceptions on the welfare impacts. Furthermore, while many external factors may increase the risk and occurrence of welfare issues during the preslaughter phase of broiler chickens, stakeholders' awareness sometimes contradicted with their commercial practice. In such cases, economic drivers appear to be more important than welfare drivers. This occurred, for instance, when the stocking density was exceeded or when manual catching was preferred over mechanical catching. On the other hand, farmers' practices sometimes reflected welfare recommendations, though they were also performed for reasons beyond welfare. This was the case for nightly catching, which was mainly linked to convenience-related motives. Welfare risks were sometimes driven by technical issues. Catching firms, for example, chose to avoid defects of mechanical catching, though it may be more welfare friendly (Wolff *et al.*, 2019). Slaughterhouses were increasing waiting times, hence welfare risks, due to technical limitations of processing lines and the economic incentive to always have birds on the line during operating hours.

Based on the stakeholder views on potential welfare impacts, different knowledge gaps in broiler welfare research could be identified:

- Aside from the positive, long-term effects of spray vaccines, their potential negative impact through thermal discomfort of day-old chicks is unknown.
- Scientific evidence on the welfare impact of transporting incubated eggs is scarce.
- Studies mapping and evaluating injuries of day-old chicks during crating, and the potential role of crating method (manually or mechanically), are lacking.
- There is a need for research on optimal and welfare-friendly stocking densities of day-old chicks during holding and transporting.
- Evidence on the effectiveness and implications of panting (gasping) to evaluate heat stress during crating needs to be examined.
- Future research could focus on separate aspects of hatchery processing and holding to elucidate the effects on welfare.
- For day-old chicks, more research is needed on yolk sac reserve depletion during transportation.
- For broilers at slaughter weight, conflicting findings were reported on the impacts of the type of catcher and crate stocking density on mortality, with studies indicating either no or a positive relationship.
- Scientific evidence is lacking with regards to welfare risks associated with drivers' behaviour when loading and transporting broilers.
- Welfare impacts of climate and duration during holding and transporting need to be evaluated in studies targeting conditions that approximate current practices, rather than extreme conditions.

Despite the study's limitations, e.g. targeting Flemish stakeholders through a relatively small qualitative research sample, looking at subjective perceptions rather than objective measures, this study allows to further advance the understanding of stakeholders' perceptions of the welfare impacts from an industry perspective. Considering the similarities and differences between the findings from practice and scientific evidence, the following recommendations for future practice and research can be put forward:

- As farmers prefer manual catching over mechanical, despite their knowledge of its more adverse impacts on broiler welfare, incentives for more animal-friendly methods could be explored. For example, an alternative, most likely expensive manual catching method is the 'Swedish catching method', where both hands are used to hold two birds upright by their abdomen (Eilers *et al*., 2009). Findings point out fewer injuries and a larger consistency in crate stocking densities as compared to conventional inverted handling (Kittelsen *et al*., 2018).
- Innovations need to be continued in mechanical catching methods in a way that minimally stresses or damages the birds before they are slaughtered.
- Given the awareness of stakeholders regarding environmental conditions, improvement of transportation conditions could be further promoted. Duncan (1989), for example, concluded that chickens are calmer and less affected by the catching process if they are handled in darkness.
- Initiatives to increase the low awareness of the specific legislation regarding feed withdrawal and fasting could reduce the large discrepancies in time windows in current practices.
- Welfare risk factors, like duration and thermal conditions of stages, could be further tackled through collaboration and coordination along the chain, ensuring better alignment of the different activities and a higher degree of commitment towards broiler welfare responsibilities.
- Efforts are needed to further evaluate and improve the current penalty system for farmers to include other stakeholders, as farmers are not the only responsible party when it comes to broiler welfare.
- To further avoid the different negative welfare impacts of current hatching activities, the potential of on-farm hatching could be further examined (De Jong *et al*., 2017).

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ORCID

Leonie Jacobs http://orcid.org/0000-0002-3799-5078
Hans De Steur http://orcid.org/0000-0003-1340-0882
Xavier Gellynck http://orcid.org/0000-0002-8908-3310
Frank Tuyttens http://orcid.org/0000-0002-1348-218X

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