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## Animal welfare during transport: comparison of mortality during transport from farm to slaughter of different animal species and categories in the Czech Republic

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### ABSTRACT

Animals may be subjected to various stressors during transport, which may compromise their health and welfare as well as meat quality. In the chain of operations between a farm and a slaughterhouse, animal transport is probably the most stressful and injurious stage. Data on mortality is commonly collected at slaughterhouse as a retrospective indicator of animal welfare during transport. Ten-year prevalence of mortality of all the species and categories of animals (cattle, pigs, goats, sheep, poultry, rabbits and ostriches) regularly scheduled for slaughter in the Czech slaughterhouses was assessed as dead on arrival after road transport from 2010 to 2019. Among livestock, the highest mortality was found in pigs (0.065%); statistically higher compared to cattle (0.027%) and sheep (0.015%). In animals shipped in containers (rabbits, broiler chickens, end-of-lay hens, turkeys, geese and ducks), the highest prevalence was found in laying hens (0.507%), statistically higher compared to broiler chickens (0.425%) and rabbits (0.199%). The lowest prevalence was observed in geese (0.003%). There was a trend for decreasing death losses of pigs in more recent years and losses in broiler chickens and ducks increased. The results indicate that the current transport conditions should be re-evaluated for poultry. Emphasis should be put on the assessment of animal fitness before transport. This is especially important for animals at the end of their production cycle such as dairy cows, sows, and laying hens. They were more likely to die during the journey.

### HIGHLIGHTS

- Dead on arrival is an animal-based measure commonly applied at slaughterhouse as a retrospective indicator of animal welfare during transport.
- In a cross-species comparison, the highest prevalence was observed for animals transported in cages and for end of production cycle animals.
- To reduce mortality, several factors have to be considered by the meat industry other than the species-related ability to cope with transport.

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Dead on arrival; livestock; poultry; rabbits; road transportation in cages

## Introduction

The conditions provided to animals during transport in the European Union must follow the animal protection legislation (European Council Legislation 2005) and, although they have generally improved by its adoption, there are still possible shortcomings that affect the welfare of transported animals in the Czech Republic and likely in the other Member States. Animals, as sentient beings, have a value independent of their usefulness to humans and should not be thought of as purely money-based products and one

of the main ethical concerns in animal husbandry is, indeed, their welfare at the end of their lives, during the slaughter process and related operations (Browning and Veit 2020). Wherever possible, the humane operation must be adopted and animals intended for human consumption should be slaughtered as near as possible to the farm of origin considering the acquired scientific evidence concerning the relationship between travel time and welfare outcomes (Mitchell and Kettlewell 2008). It is likely that farm animals experience a period of impaired welfare

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towards their end of life. Transport and lairage prior to slaughter, in particular, are stress factors that can seriously deteriorate the health of animals and are considered among the features that impair their welfare (Flores-Peinado et al. 2020). The word welfare is only applicable while an animal is alive, but a period of poor welfare typically precedes death during handling and transport. Since only animals fit for transport can be transported (European Council Legislation 2005), all animals should be checked before transport and thus be healthy when starting their journey. If they arrive dead, the conditions of the journey were not suitable for them. However, the same conditions were applied also to the surviving animals and they have likely experienced impaired welfare for part or all of the duration of the journey as well.

Under commercial conditions, it is difficult to establish the causes of mortality in transit and there are few studies available that have provided such information. According to Norris et al. (2003), the main causes of cattle death during transport are heatstroke, trauma and respiratory diseases. Heart failure is a primary cause of mortality during the transport of pigs (Zurbrigg et al. 2021). Cardiac abnormalities associated with heart failure were the most consistent pathology found in pigs that died in transit (Zurbrigg et al. 2017a). In broiler chickens, macroscopic pathological lesions were found in 89.4% of dead birds (Nijdam et al. 2006). Infectious disease states were the main cause of lesions (64.9%) followed by heart and circulation disorders (42.4%) and trauma (25%). Whiting et al. (2007) identified acute heart failure in 36% of dead birds, air sacculitis/pneumonia in 1% and chronic heart failure/ascites in 12% of the dead birds.

Transported animals are mostly affected by stressors that different species and categories of animals cope with differently. Animals can adapt to short-term stress, but the combined action of several stressors can negatively affect their health and welfare. The major stress factors influencing animals during transport include physical stress such as pre-transport control, on-farm catching and loading, the density of animals, multiple environment conditions such as temperature and humidity changes, transport duration, management of water and feed and other animals-, vehicle- and driver-related factors (Nielsen et al. 2011; Schwartzkopf-Genswein et al. 2012; Simova et al. 2017; Cockram and Dulal 2018). Psychological stress is usually caused by a new and unknown environment with its noises and odours or by mixing with unfamiliar animals (Grandin 1997). The methods of handling and road transport vary among different species and

categories of animals transported as well as their ability to cope with transport conditions and related operations. Livestock is driven into the vehicle individually or in groups and enters the cargo area via ramps, bridges and gangways (Schwartzkopf-Genswein and Grandin 2014), whereas poultry and rabbits are transported in stackable crates placed on vehicles in multi-floor crate stands (Liste et al. 2008). Each species and category are susceptible to different key stress factors among features and management of each operation according to age, size and condition. In this context, it is difficult to have a standardised animal-based measure that retrospectively provides information on animal welfare during transport comparable across species and categories. Thus, mortality records are often the only documentation that offers information about animal health during the journey underlining the seriousness of issues occurring during live animal transportation and related operations.

It was the aim of this study, therefore, to perform a cross-species comparison of the prevalence of transport-related mortality assessed as dead on arrival (DOA) of all species and categories of animals transported to slaughterhouses in the same geographic area (Czech Republic) during the same period of time (1 January 2010 to 31 December 2019).

## Material and methods

The prevalence of mortality of all the species and categories of animals regularly scheduled for slaughter was assessed as dead on arrival at the slaughter after road transport during the veterinary inspections carried out by the official veterinary inspectors of the State Veterinary Administration (a public administration body under the Ministry of Agriculture of the Czech Republic). The transport of animals from farms to slaughterhouses was carried out by means of road transport using trucks specifically designed for the transportation of animals of the given species. The transport conditions (including stocking density) for all journeys were in compliance with Council Regulation (EC) No 1/2005 on the protection of animals during transport and related operations (European Council Legislation 2005). At any time during the journey, whether the means of transport was stationary or moving, they were required to be capable of maintaining a range of temperatures from 5 °C to 30 °C within the means of transport, for all animals, with a +/- 5 °C tolerance, depending on the outside temperature. The State Veterinary Administration did not issue a permit for any transport of animals when there was a risk of

**Table 1.** Prevalence of dead-on-arrival (DOA) of animals transported for slaughter in the Czech Republic from 2010 to 2019.

Animal species/category	Number of transported animals	DOA (number)	DOA (%)
Animals transported in a vehicle			
Dairy cows	1137256	502	0.044
Feeders/heifers	257931	19	0.007
Fattening bulls	1015601	60	0.006
Calves	104557	98	0.094
Sows	587351	1106	0.188
Finishing pigs	25042633	15330	0.061
Piglets	123520	329	0.266
Ewes	22821	6	0.026
Lambs	114278	14	0.012
Does	1350	2	0.148
Kids	5778	0	0.000
Ostriches	6252	0	0.000
Animals transported in containers			
Broiler chickens	1094054474	4647787	0.425
Laying hens	20132832	102088	0.507
Turkeys	1182971	1373	0.116
Geese	37691	1	0.003
Ducks	28613090	33325	0.116
Rabbits	1880670	3741	0.199

thermal stress (namely during extremely hot summer days). The Czech Republic has a temperate climate, situated in the transition zone between the oceanic and continental climate types, with warm summers (with daytime temperatures 20–25 °C, but sometimes even 30 °C or more) and fairly cold winters (with daytime temperatures usually around zero in the coldest month). The temperature difference between summer and winter is due to the landlocked geographical position.

The data were collected in the central database of the State Veterinary Administration, from which they were then extracted for analysis retrospectively. The prevalence of DOA was monitored during a ten-year period (from 2010 to 2019) within the Czech Republic. All consignments of live animals transported from Czech farms to any slaughterhouse in the Czech Republic (namely 226 cattle slaughterhouses, 209 pig slaughterhouses, 146 sheep slaughterhouses, 81 goat slaughterhouses, 9 rabbit slaughterhouses, 36 broiler chicken slaughterhouses, 15 end-of-lay hen slaughterhouses, 26 turkey slaughterhouses, 9 goose slaughterhouses, 18 duck slaughterhouses and 3 ostrich slaughterhouses) were included in the analysis. Prevalence of DOA per species and category was calculated as the ratio between the number of animals died over the total number of transported animals.

The comparisons of DOA were assessed in bovine, porcine, ovine and caprine species and in ostriches (animals transported in the vehicle) and in poultry and rabbits (animals transported in containers). In livestock, DOA prevalence was compared in adult animals (dairy cows, sows, ewes and does), fattened animals (feeders/heifers, fattening bulls, finishing pigs, lambs

and kids), young animals removed from fattening (calves and piglets). Also in poultry and rabbits, DOA prevalence was compared between adult animals (end-of-lay hens) and animals raised for meat (broiler chickens, turkeys, geese, ducks, and rabbits).

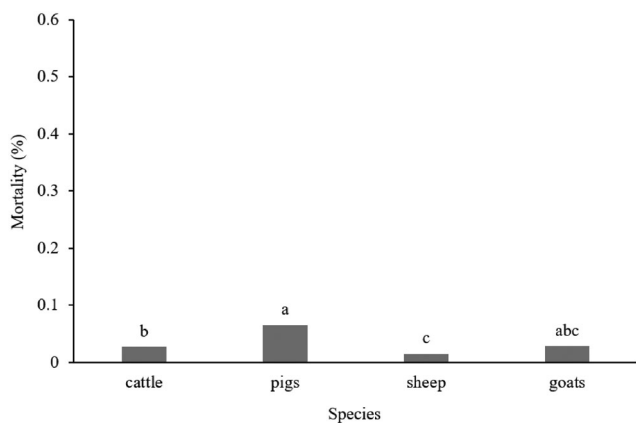
Prevalence data were statistically analysed using Unistat v. 6.5 (Unistat Ltd., London, UK) and they were compared applying the Chi-square test to evaluate statistical significance within a 2 × 2 contingency table procedure. At frequencies exceeding 5, the Yates correction was used, at frequencies below 5, the Fisher's exact test was used. To assess the trend overtime during the monitored years, Spearman's rank correlation coefficients were calculated. A *P*-value equal or smaller than .05 was considered significant.

## Results

The total number of animals transported for slaughter, the number of animals found dead on arrival and DOA prevalence of freely moving livestock (cattle, pigs, sheep and goats) transported in vehicles and of poultry (broiler chickens, end-of-lay hens, turkeys, geese and ducks) and rabbits transported in containers are shown in Table 1. No death was recorded among the 6 252 ostriches transported for slaughter during the monitored period.

A comparison of overall DOA prevalence for cattle, pigs, sheep and goats is shown in Figure 1. The highest incidence of DOA was found in pigs (0.065%), significantly (*P* < .05) lower DOA prevalence was found in cattle (0.027%) and sheep (0.015%).

Interspecies comparisons revealed the highest DOA prevalence among culled adult animals (dairy cows,



**Figure 1.** Comparison of the prevalence of dead on arrival for cattle, pigs, sheep and goats. <sup>a-c</sup>values with different letters are significantly different for  $P < .05$ .

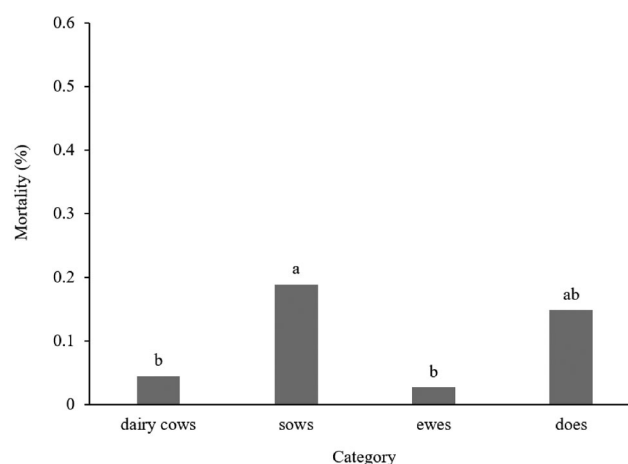
sows, ewes and does) in sows (0.188%) (Figure 2). Among fattened animals (feeders/heifers, fattening bulls, finishing pigs, lambs and kids) the highest incidence of DOA was found in finishing pigs (0.061%) as shown in Figure 3. The DOA prevalence in young animals removed from farms (calves and piglets) shown in Figure 4 was higher for piglets than for calves (0.266% vs. 0.094%;  $P < .05$ ).

The comparison of prevalence of dead on arrival for animals transported in containers, i.e. poultry (end-of-lay hens, broiler chickens, turkeys, geese and ducks) and rabbits, is shown in Figure 5. The highest incidence of DOA was recorded in end-of-lay hens (0.507%). Mortality during transport was significantly ( $P < .05$ ) lower in fattened poultry and rabbits. Of the fattened animals, the highest mortality rates were observed in broiler chickens (0.429%) and rabbits (0.199%) while the lowest mortality was found in geese (0.003%).

Results of the Spearman rank correlations of the 10-year data within the animal category showed a significantly decreasing trend over years for finishing pigs and piglets ( $R_s < -0.83$ ;  $P < .02$ ) and a significantly increasing trend over years for broiler chicken and ducks ( $R_s > 0.70$ ;  $P < .05$ ).

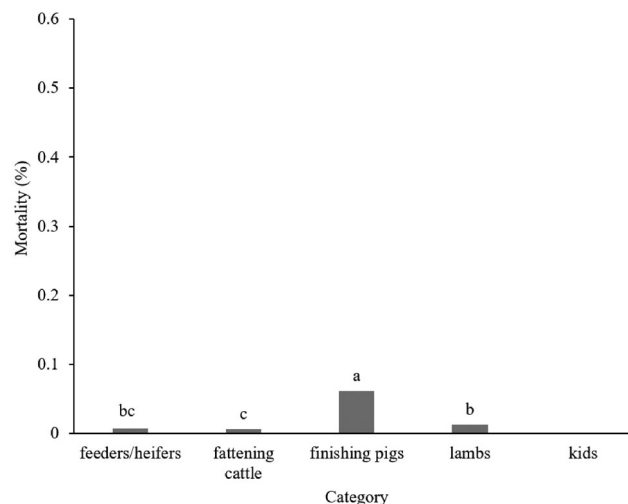
## Discussion

Currently, the only animal-based measure that is recorded by the official veterinarians in slaughterhouses of most European Union Member States that is straightforwardly related to animal welfare during transport is the mortality rate, assessed as dead on arrival. In the Czech Republic, considering the size of the country (majority of animals were transported for distances less than 200 km), the transport operation

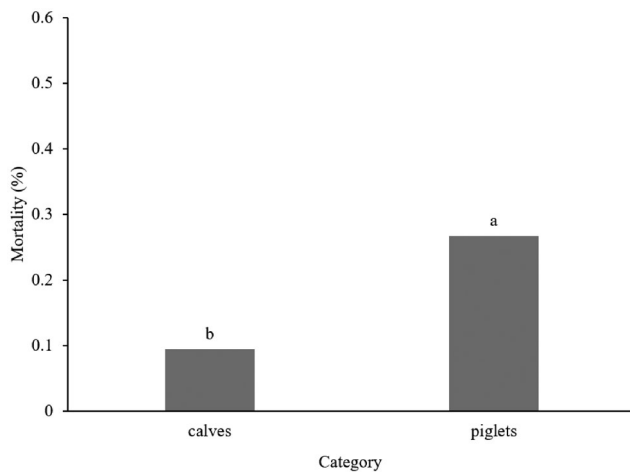


**Figure 2.** Comparison of prevalence of dead on arrival for adult bovine, porcine, ovine and caprine animals. <sup>a,b</sup>values with different letters are significantly different for  $P < .05$ .

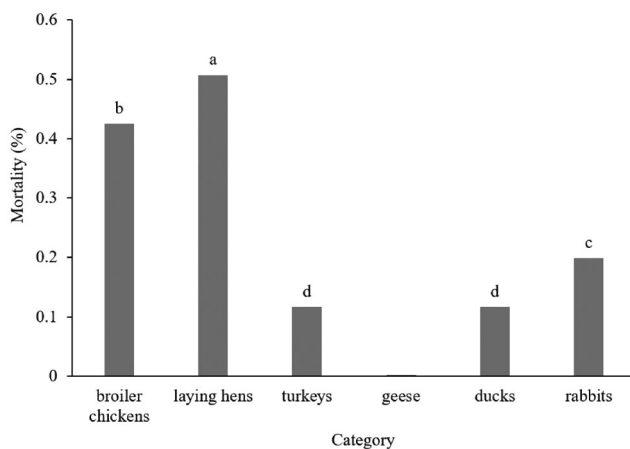
can be relatively short when animals are transported from Czech farms to Czech slaughterhouses as was the case of all journeys monitored in our study (the journey duration must not exceed 8 hours by law). However, significant differences were found in transport-related mortality rates between different species and categories of transported animals. The results show that the sensitivity to handling and transport conditions during transport to the slaughterhouse differs depending on the species and categories of animals, which is reflected in the DOA rates. The overall prevalence of DOA was low, but, the transport conditions differ dramatically between freely moving animals (cattle, pigs, goats and sheep) and animals



**Figure 3.** Comparison of prevalence of dead on arrival for fattened bovine, porcine, ovine and caprine animals. <sup>a-c</sup>values with different letters are significantly different for  $P < .05$ .



**Figure 4.** Comparison of prevalence of dead on arrival for calves and piglets removed from farms. <sup>a,b</sup>values with different letters are significantly different for  $P < .05$ .



**Figure 5.** Comparison of prevalence of dead on arrival for poultry and rabbits transported in containers. <sup>a-d</sup>values with different letters are significantly different for  $P < .05$ .

transported in containers (poultry and rabbits), the two groups were analysed separately.

In freely moving animals, the greatest transport-related mortality was found in pigs. Considering the varying fitness of culled adult animals, fattened animals and young animals removed from farms at the time of transport (as shown by previous research by e.g. Schwartzkopf-Genswein et al. 2012; Fogsgaard et al. 2018), we compared the incidence of DOA not only among the species but also within the categories of animals. The highest transport-related mortality rates were found in pigs in all groups. Sows were more likely to die during transport than dairy cows and ewes; finishing pigs had a significantly higher incidence of DOA than feeders/heifers, fattening bulls, lambs and kids; higher mortality was found in piglets

than in calves. Pigs are more unstable compared to ruminants in response to inappropriate welfare conditions, improper handling and stress (Costa da et al. 2014). Also, the biological constitution given by the performance of the circulatory system to the proportions of the body volume, muscle and fat content (Lonergan et al. 2019) predisposes pigs to more frequent circulatory (heart) failure compared to ruminants (Zurbrigg et al. 2017b). During physical activity, pigs are thus more predisposed to muscle exhaustion, overheating and circulatory failure. The result is a higher level of mortality in pigs under inadequate welfare conditions, inappropriate handling and the stress burden associated with transport to a slaughterhouse than in ruminants. According to Rioja-Lang et al. (2019), the welfare of pigs during transport is affected namely by the vehicle design, pre-transport fasting, the control of environmental conditions and loading density. A higher loading density increases the risk of a pig becoming non-ambulatory or dying during the journey. Averós et al. (2008) found that the risk of mortality was double for pigs not fasted before being loaded irrespective of whether the pigs were injured or not. According to Warriss (1994), the death of unfasted pigs during transport resulted mainly from full stomach pressure on the vena cava, resulting in decreased blood flow quality. Fasting before slaughter prevents pigs from vomiting in transit and developing hyperthermia (Dalmau and Velarde 2016). To ensure the beneficial effects of fasting, feed should be withdrawn more than 4 h before transportation (Warriss et al. 1998); however, the total fasting period should not exceed 18 h (Dalmau and Velarde 2016), as an extended fasting period causes hunger and aggressiveness (Warriss 1994). Both proper fasting and ensuring sufficient space allowance can be achieved with limited costs by careful planning of the journey and training of workers responsible for loading pigs. Changing the transport vehicle and control of the environmental conditions (e.g. the installation of an adequate ventilation system) may be expensive, but given the high transport-related mortality in all categories of pigs found in this and other recent studies (Schwartzkopf-Genswein et al. 2012; Peterson et al. 2017) and well-established impact of these factors on pig mortality, it has to be considered.

Cattle are relatively resistant to inappropriate welfare conditions, improper handling and stress load associated with transport to the slaughterhouse (Schwartzkopf-Genswein et al. 2012). This is especially true for young animals, i.e. feeders/heifers and fattening bulls, in which the transport-related mortality was

minimal (0.007% and 0.006%, respectively). A significantly higher number of deaths were recorded in bovine animals transported to the slaughterhouse due to culling. The majority of calves slaughtered in the Czech slaughterhouses originate from the dairy industry. These are animals excluded from farms for health and fitness reasons, and such weakened calves are more susceptible to inappropriate welfare conditions, improper handling and stress associated with transport to slaughterhouses resulting in more numerous deaths of calves during transport. A comparable level of transport deaths was found in dairy cows who are also sent to slaughterhouses due to reduced productivity, often associated with impaired health and depletion of the organism exposed to intensive rearing and production (Clay et al. 2020), which is reflected in their lower resistance to transport to slaughterhouses.

In the Czech Republic, small ruminants (sheep and goats) are transported to slaughterhouses in significantly smaller numbers (hundreds to thousands) compared to pigs and cattle (hundreds of thousands to millions). Sheep and goats are usually kept extensively on smaller farms (for most of the year on pasture), often in organic farms. Deaths in connection with the transport to slaughterhouses were recorded only rarely in the monitored 10-year period (2 DOAs in does, 6 DOAs in ewes, 14 DOAs in lambs) or not at all (kids). However, despite the low DOA incidence recorded during the monitored period in our study, the transport-related mortality rates were relatively high due to the small total number of animals transported, namely in does (0.148%). Statistically, the transport-related mortality rate of does did not differ from that of sows and piglets, i.e. the categories with the highest mortality among livestock monitored in our study. Fitness of end-of-production and culled animals are often deteriorated (Stojkov et al. 2020) and even if they are considered fit for transport (based on the on-farm assessment required by the relevant EU legislation), they are more likely to struggle with the transport conditions than market-ready animals (Cockram 2019).

Finishing pigs, feeders/heifers, fattening bulls, lambs and kids were included in the group of fattened animals in our study. In the Czech Republic, these are categories specifically intended for slaughter and meat production. They are transported to the slaughterhouse after fattening at the optimum weight for slaughter, taking into account the quality of the meat. The transport-related mortality rate of finishing pigs (average weight 115 kg) was several times higher than that of all other species. Of these species, pigs are the only animals in the Czech Republic fattened in

intensive farms, i.e. in closed halls with a controlled environment and a minimum of stimuli. This can be a significant disadvantage in dealing with sudden changes related to transport operations (e.g. changes in the environment, sensory overstimulation), which, in addition to the predisposition to circulatory (heart) failure given by their constitution (Zurbrigg et al. 2017b), may further increase the risk of their death during transport. MacGregor and Dewey (2003) reported that pathological changes in cardiac muscle including petechial haemorrhage were detected in all of the hearts examined from pigs that died during transport. On the contrary, feeders/heifers, fattening bulls, lambs and kids are traditionally reared in the Czech Republic mainly by means of grazing and during their life they are normally exposed to temperature fluctuations and other changes in the environment. They show higher physical resistance to transport conditions compared to livestock kept in intensive systems. For example, extensively reared cows may be less susceptible to heat stress due to their less intensive management (Blanco-Penedo et al. 2020). In small ruminants, the risk of heat stress is lower compared to cattle, as sheep and goats are known to be better adapted to hot environments than large ruminants. They have a better ability to survive, but also to produce and reproduce in unfavourable climatic conditions (Joy et al. 2020).

Fattening of calves and piglets is not commonly carried out in the Czech Republic; bovine and porcine animals are transported and slaughtered in this age category due to their exclusion from farms, i.e. unsuitability for further fattening, production or breeding. The decision to exclude them from the farm is usually due to the impaired health or fitness of these animals. This fact can then also be reflected in their ability to cope with the transport conditions and greater transport-related mortality rates. The incidence of DOA is particularly alarming in piglets. In our study, the transport-related mortality in piglets was not only almost threefold higher than that in calves; piglets had the highest mortality among all livestock categories monitored in our study. Significantly impaired health of piglets transported for slaughter was also documented by the high incidence of patho-anatomic findings detected during post mortem slaughterhouse inspection (Vecerek et al. 2020). The high level of mortality during transport, as well as the high incidence of emaciation and abscesses and pathological lesions in the lungs, liver, heart and kidneys found in slaughtered piglets, indicate that also piglets whose condition is not compatible with transport or the requirements for

the quality of meat for human consumption, are transported to the slaughterhouse. Our results suggest that the current on-farm assessment of the fitness of piglets for transport is insufficient and fails to recognise piglets that are likely to die during transport. Greater emphasis needs to be placed on the identification of piglets not fit for transport. These piglets must, in compliance with relevant EU legislation, be killed on a farm and not transported to slaughterhouse.

Among animals transported in containers (poultry and rabbits), the greatest transport-related mortality rate was found in end-of-lay hens (0.507%). A number of studies (e.g. Petracci et al. 2006; Martino di et al. 2017; Vecerkova et al. 2019) have pointed out high mortality in laying hens during transport. Laying hens are transported to the slaughterhouse after the end of the intensive laying period, i.e. in a lower health and fitness condition than fattened poultry or rabbits as documented by results of slaughterhouse post-mortem examination (Vecerek et al. 2019; Nincakova et al. 2022). As a result, laying hens might be less resistant to transport operations. In the case of animals transported in containers, especially poultry caught in large numbers, the fitness for transport control during container storage is often limited and animals in poor condition are also transported (Cockram 2019). During transport, the inspection of animals in containers is practically impossible, so the condition of the consignment is assessed only when unloaded at the slaughterhouse. A reduction in the level of deaths during transport could thus be achieved in particular by improving the conditions of the birds being transported (stronger skeleton, better plumage thanks to improved housing systems on egg farms), or a more thorough on-farm assessment and exclusion of unfit birds from transport. Furthermore, the reduction of DOA can also be achieved by improving the conditions during transport, particularly by maintaining the temperature within the transport container preventing birds from thermal stress as both heat and cold stress were documented to increase DOA rates significantly in transported poultry (e.g. Petracci et al. 2006; Weeks et al. 2012; Martino di et al. 2017).

Among poultry and rabbits raised for meat production, broiler chickens showed the highest level of deaths. The poor condition of broiler chickens has been pointed out for a long time. As a result of decades of selection for a rapid growth rate as well as for high carcass yields, broiler chickens are predisposed to heart and leg problems, especially ascites and sudden death syndrome (Meluzzi and Sirri 2009; Dierick et al. 2019; Rayner et al. 2020). The deteriorated health

may subsequently reduce the ability of chickens to cope with transport handling and stress. According to Ritz et al. (2005), flock health status attributed to 39% of the transport-related deaths of broiler chickens recorded in their study. However, the major cause of mortality, accounting for 61% of DOA birds in their study, was a physical injury due to rough handling by the catch crew or by machinery malfunction or disrepair. Therefore, when trying to improve the welfare of birds during transport and reduce DOA, careful handling during catching and loading has to be ensured. Particularly birds caught manually are prone to injuries when the common industry practice of catching and carrying birds by one leg is used (Knierim and Gocke 2003). Rabbits showed a significantly lower incidence of mortality compared to broiler chickens. A rabbit is considered an animal species sensitive to inappropriate welfare conditions, improper handling and stress (Verga et al. 2009). This well-known fact is thus probably taken into account in the method of catching, loading and transport for slaughter and to some extent offsets the absence of more detailed legislative rules for the transport of rabbits. Nevertheless, the 0.199% of rabbits that were DOA is not a negligible amount, considering they were young healthy animals presumably with no pre-existing farm conditions limiting their ability to cope with the transport operations. The mortality rates of ducks and turkeys were comparable significantly lower than in broiler chickens and rabbits. Research into welfare of other poultry than broiler chickens and end-of-lay hens during transport is limited and data on the incidence of DOA is lacking. For comparison, only previous studies from the Czech Republic are available, reporting a similar incidence of mortality for turkeys and ducks (Voslářová et al. 2007, 2016; Machovcova et al. 2017); and for turkeys also two Italian studies showing significantly higher rates of mortality (Petracci et al. 2006; Martino di et al. 2017). Fattening of turkeys and ducks has considerable national specifics (method of fattening, breed/hybrid, required carcass size); in addition, different climatic conditions are involved in transport, making international comparisons difficult. However, even in the Italian studies, the level of turkey mortality was significantly lower than the DOA of laying hens transported to slaughterhouses in the same area and period, thus confirming the need to focus primarily on the welfare of laying hens during transport. Catching and carrying methods that are commonly used in laying hens and broiler chickens and have been shown to be associated with stress and a higher risk of injury (Kittelsen et al. 2018), are prohibited in ducks, geese and



turkeys. According to the Czech legislation, ducks and geese may not be carried upside down or lifted by the legs only; they must be supported by a hand placed under their body and an arm around their body so that the wings remain close to the body. Heavier animals must be handled individually. Turkeys must not be lifted by one leg only. If turkeys are carried, they must be carried individually, using methods appropriate to their size and weight. Small turkeys must be held by both legs or must be resting on the arm and body of the person performing the capture. Larger turkeys must be carried by one leg and the diagonal wing. The lowest transport-related mortality among animals transported in containers was found in geese and actually, only one DOA goose was recorded during the monitored period. It can be assumed that the low mortality is a result of appropriate capture treatment (specific requirements for capture handling set by legislation) and the good condition of birds when moved to the slaughterhouse, resulting, *inter alia*, from the ban on forced feeding and the ban on mutilation in the Czech Republic. The seasonal organisation of geese fattening in the Czech Republic is also likely to manifest when the transport to the slaughterhouse usually takes place in the autumn, so during the transport, there are no effects of extreme temperatures in the summer or winter months. However, there are no data on the effect of temperature on transport-related mortality to corroborate this assumption.

The transport of ostriches substantially differs from the transport of other bird species, but also from other animals shipped to the slaughterhouse due to their size, value and specific handling requirements. A positive outcome is that no deaths were reported during the transport of ostriches, as opposed to all other species and categories monitored in our study where deaths occurred during transport to the slaughterhouse (with the exception of kids).

## Conclusion

There are several reliable animal-based measures that may be recorded at slaughter to monitor animal welfare retrospectively, however, DOA is the measure that is currently recorded in most EU Member States at regular veterinary inspections both for human-safety related purposes and as a very late and severe, but reliable animal welfare measure. The results of the study show that DOA is a reliable animal-based measure to differentiate the response of different animal species and categories to road transport and related operations. Animals moved in containers might seem

more susceptible to transport-related mortality. The greatest DOA prevalence was observed in laying hens at the end of their production cycle, and, in general, culled animals were more likely to be found dead on arrival at the slaughterhouse. Another category that needs a revision of the current transportation conditions are pigs. Along with the need for re-evaluation of the transport conditions for domestic chickens, both hens and broilers, that are particularly prone to die during the journey.

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## Author contributions

LV: Methodology, Data Curation, Formal analysis. VV: Conceptualisation, Methodology, Formal analysis, Supervision. EV: Writing – original draft preparation, Project administration, Funding acquisition, Writing – Review and Editing. DT: Writing – original draft preparation. MB: Visualisation, Writing – Review and Editing. All authors have read and agreed to the published version of the manuscript.

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## Data availability statement

Data for analysis were obtained from the information system of the State Veterinary Administration of the Czech Republic. Data are available from the corresponding author on request.

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