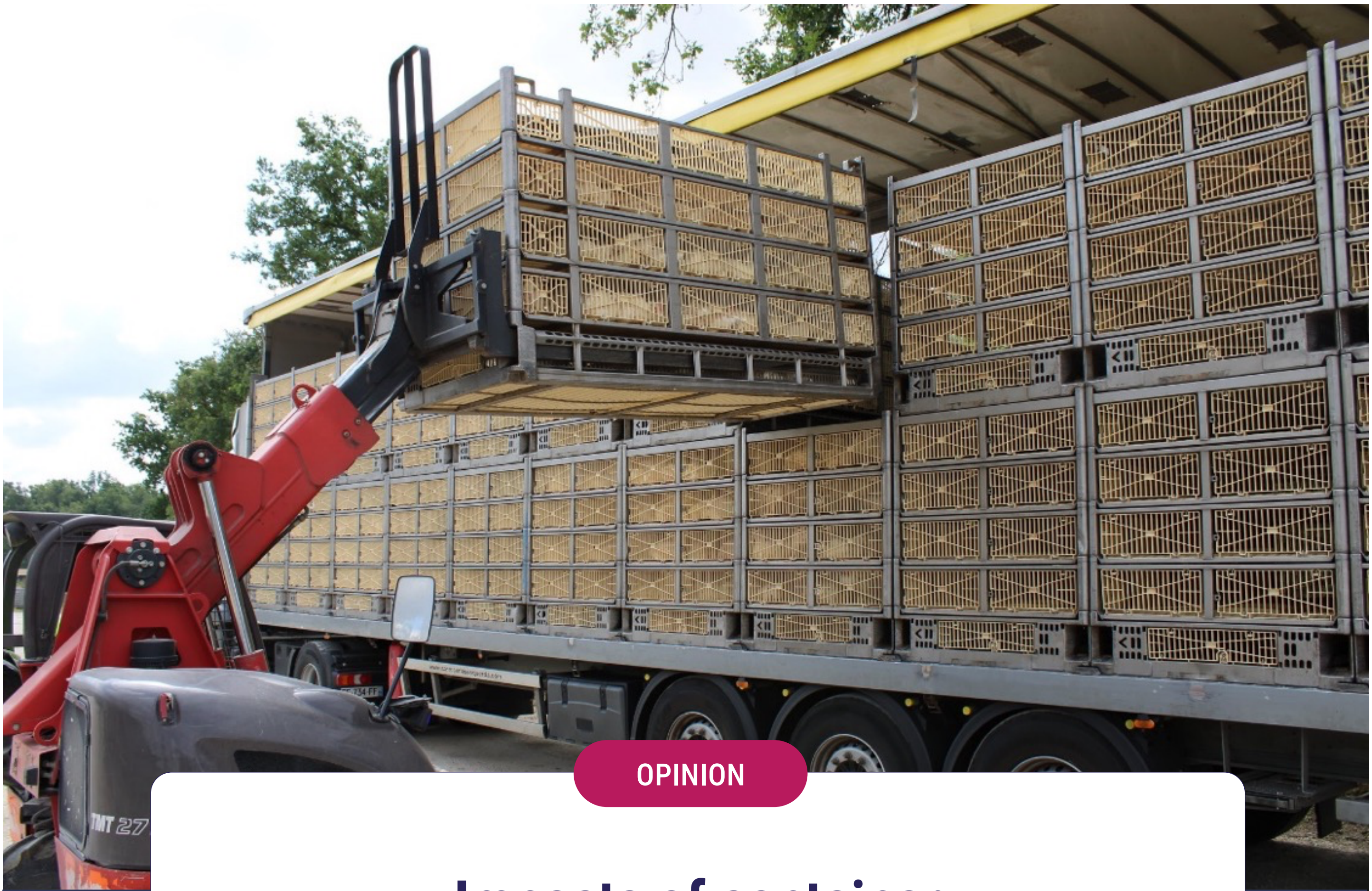
French Reference Centre for Animal Welfare



OPINION

Impacts of container internal loading density and height on the risks of overlapping and injury in poultry during transport

Original title in French

Impacts de la densité et de la hauteur des caisses de transport sur le risque de chevauchements et de blessures des volailles

APRIL 2026

Impacts of container internal loading density and height on the risks of overlapping and injury in poultry during transport

Requested by
Animal Welfare Office (BBEA) of the General Directorate for Food (DGAL), French Ministry of Agriculture and Food Sovereignty

Date of request
28/08/2024

Date delivered by the FRCAW
14/11/2025

Date of most recent version in French
10/04/2026

Date of publication in English
13/04/2026

Coordinated by
Anne-Lise Dauphiné-Morer, CNR BEA

Translated into English by
Teresa Bridgeman

English editorial work by
Teresa Bridgeman, Agnès Tiret

Suggested citation for the English version

Anne-Lise Dauphiné-Morer, Lisa Diaz, FRCAW experts, Geneviève Aubin-Houzelstein. Opinion of the FRCAW on the impacts of container internal loading density and height on the risks of overlapping and injury in poultry during transport. FRCAW / CNR BEA. 2026. Translated by Teresa Bridgeman

DOI: 10.17180/kncj-rx25

Suggested citation for the original report in French

Anne-Lise Dauphiné-Morer, Lisa Diaz, Experts du CNR BEA, Geneviève Aubin-Houzelstein. Avis du CNR BEA sur les impacts de la densité et de la hauteur des caisses de transport sur le risque de chevauchements et de blessures des volailles. CNR BEA. 2025.

DOI: 10.17180/yez7-xk53

Summary

In 2023, a proposal for a regulation on the protection of animals during transport was published, repealing Council Regulation (EC) No 1/2005. The new text proposes a revision of the rules on space allowances in transport containers (floor area and container height) based on the recommendations of the EFSA opinion on the welfare of domestic birds and rabbits transported in containers (EFSA, 2022). The present report from the French Reference Centre for Animal Welfare (FRCAW) summarises the key points of the EFSA opinion (EFSA, 2022), focusing exclusively on information relating to overlapping and injuries associated with loading density inside transport containers. In addition, it provides an in-depth analysis of the scientific literature on the impacts of these different densities/space allowances on behaviours, physiology and the injuries observed on carcasses. The report also highlights the factors that can increase overlapping and injuries in poultry during transport, and proposes levers for action to reduce their incidence. Only a few studies have examined the impacts on overlapping behaviours and the risk of injury to poultry of the container floor areas and heights set out in the proposed regulation. The results of these few studies support three main hypotheses: 1) an increase in the space allowance (container floor area and height) reduces the harmful effects of restricted movement; 2) an increase in the space allowance would appear to increase the number of injuries, but the data do not allow conclusions to be drawn concerning the origins of these injuries, which could have occurred in transport phases other than the journey itself; and 3) a transport container height that allows birds to sit in a natural posture with their heads up without their combs touching the ceiling and to move around and change posture inside the container, but which prevents them from standing in a natural position, limits the stress caused to the birds without increasing injuries caused by overlapping. However, further studies are needed to confirm existing results and increase understanding of them, taking into account the potential exacerbating factors discussed in this report. Last, there is a need for studies to be conducted on each of the species concerned.

Keywords

Transport / Containers / Crates / Density / Height / Surface area / Injuries / Overlapping / Poultry

Background

The European Commission has announced its intention to revise all EU regulations relating to the welfare of farm animals during transport. In December 2023, the European Commission published its Proposal for a Regulation of the European Parliament and of the Council on the protection of animals during transport and related operations, amending Council Regulation (EC) No 1255/97 and repealing Council Regulation (EC) No 1/2005 currently in force. This revision was initiated in order to bring the regulatory requirements into line with new scientific knowledge on animal welfare during transport, based on opinions issued by the European Food Safety Authority (EFSA) at the request of the European Commission. Negotiations between Member States are currently in progress (2026).

Context as defined by the requesting body

'The proposed regulation suggests lower densities (higher space allowances) than those in Regulation 1/2005, to improve the space available to the animals and hence their welfare.

Professional organisations in the sector argue that the densities laid down in the current regulation mean that animals transported by road would be less likely to fall, due to 'mutual support' between animals. They thus suggest that, if lower densities were applied as recommended in the draft regulation, the animals would be more likely to fall, lose their balance and therefore injure themselves, which would have negative impacts in terms of animal welfare.

Request

For the FRCAW to answer the following question as fully as possible:

> Is it the case that [poultry][1] transported by road at the densities [and heights] set out in the proposed regulatory revision to Regulation 1/2005 are more at risk of [overlapping] and/or injuring themselves than [poultry] transported by road at the densities [and heights] laid down in the current Regulation (Regulation 1/2005)?

The FRCAW will address only the transport of poultry by road in this report, excluding the transport of chicks, which is not included in the scope of the question.

Reference documents

- COUNCIL REGULATION (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97 *In-text references and bibliography: Council of the European Union (2004)*
- Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the protection of animals during transport and related operations, amending Council Regulation (EC) No 1255/97 and repealing Council Regulation (EC) No 1/2005 *In-text references and bibliography: European Commission (2023)*

[1] Exact wording of the request: 'Is it the case that animals transported by road at the densities set out in the proposed regulatory revision to Regulation 1/2005 are at greater risk of falling and/or injuring themselves than animals transported by road at the densities specified in the current regulation (Regulation 1/2005)?' The referral concerns several species, but this report is limited to poultry. The wording has also been adjusted for the purposes of the present report to match the particular conditions under which poultry are transported.

+ EFSA AHAW Panel (2022). Welfare of domestic birds and rabbits transported in containers. EFSA Journal 2022; 20(9):7441, 188 pp. https://doi.org/10.2903/j.efsa.2022.7441. *In-text references: EFSA (2022)*

> VIEW ALL WORK CARRIED OUT BY THE FRCAW

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Glossary (English version)

Container (crate, drawer, box)

'Any crate, box, receptacle or other rigid structure used for the transport of animals, but not the means of transport itself' (EFSA, 2022). Although 'crate' is frequently used in the literature, being a very common form of container used on the ground, this report follows the EFSA opinion in its use of 'container', permitting consideration of the full range of designs currently in use.

Crate

See 'Container'.

Crating and uncrating

Used where required to designate the loading of birds into containers (as opposed to the loading of the containers into the lorry), and the removal of the birds from the containers either immediately on arrival, in lairage, or in the abattoir.

Injury

Any damage to the skin, which may take the form of small superficial punctiform pecks (holes), scratches, or larger open wounds deeper than the skin (Welfare Quality Network, 2019), which can be described as soft-tissue lesions (see EFSA, 2022). In the particular case of poultry, the term injury also refers to bone lesions and broken bones (including fractures and dislocations), and integument damage (EFSA, 2022).

Journey duration (EU 'journey time')

As defined for all animals by the European Commission, this is the length of time during which animals are transported, including the time taken to load and unload them (European Commission, 2023).

However, given the particular nature of the transport of birds in containers, the EFSA chooses to make a distinction between 'journey duration' and 'transport duration'. The latter designates a longer period, as birds spend additional time in the containers both before and after loading and unloading, including the on-farm feed withdrawal period.

Loading density inside transport containers

Ratio between the number (or preferably live weight) of animals and the surface area in the transport container (Buckham-Sporer et al., 2023). Expressed for poultry in kg/m² or cm^2 /bird. In the present report, 'loading density' unless stated otherwise, refers to this density, not to the 'overall' density of the containers as loaded in the vehicle.

Overlapping

'Overlapping' refers to all behaviours, voluntary or involuntary, where birds, or parts of birds cover each other. This can include birds climbing on top of each other, or the overlapping of wings or feet where there is insufficient space. When cold or frightened, birds may huddle together. In what is also known as 'piling' behaviour, birds cluster densely together, which can lead to injuries, heat stress, smothering and death.

Space allowance

Area per animal (expressed in cm^2/animal), generally calculated based on the weight and body size of the animals (Petherick, 2007). Where appropriate, the English version of this report follows the EFSA in differentiating between 'floor space allowance' (floor space) and 'vertical space allowance' (head height).

Stress

Stress, including in animals, refers to the presence of negative emotional states. These states occur when the animal feels threatened, whether the threat is real or not. In order to adapt to this threat, the animal responds through its behaviour, with reactions of fight or flight if it is afraid, for example, and through its physiology, with an increase in heart rate and the secretion of certain hormones to enable physical effort, among other things.[2]

Thermoneutral Zone (TNZ)

The thermoneutral zone marks the range of ambient temperatures within which metabolic rate and heat production of a homeothermic individual remain fairly minimal and stable independently of the ambient temperature. The zone is bounded by the lower critical temperature and the upper critical temperature (Bracke et.al, 2020).

Transport

The movement of animals effected by one or more means of transport, and the related operations, including loading, unloading, transfer and rest, until the unloading of the animals at the place of destination is completed (Council of the European Union, 2004) [3]. For transport in containers, related operations include preparatory on-farm feed withdrawal and time spent by animals in containers after the latter have been offloaded from the vehicle (EFSA, 2022).

Transport duration

Term specifically used in EFSA (EFSA, 2022) to designate a longer period than the 'journey duration' applicable to the transport of all farm animals. This designation is needed because, in the particular case of transport in containers, animals spend additional time in the containers both before and after loading and unloading, including the preparatory on-farm period of feed withdrawal (see 'Transport'). See also 'Journey duration'.

[2] Definition proposed by the French Reference Centre for Animal Welfare (FRCAW)
[3] NB The term associated with this definition in the original regulations is 'journey' (Council of the European Union, 2004)

List of abbreviations

ALAT

Alanine aminotransferase

AST

Aspartate aminotransferase

CK or CPK

Creatine kinase or Creatine phosphokinase

Cortisol, lactate and glucose

Physiological markers of stress

DOA or DAU

'Dead on arrival' or 'dead at unloading'

FRCAW

French Reference Centre for Animal Welfare

MCH, MCHC and MCV

Mean Corpuscular Haemoglobin, Mean Corpuscular Haemoglobin Concentration and Mean Corpuscular Volume

NEFAs

Non-esterified fatty acids

PCV

Packed Cell Volume (haematocrit)

T3, T4 and TG

Triiodothyronine, Thyroxine and Triglycerides

TBARS

Thiobarbituric acid reactive substances (providing an estimate of plasma lipid peroxidation)

TRACES

Management platform that enables the tracking of the transport of live animals in Europe

Tables and figures

Tables

Figures

1 Methodology

This document summarises the available data on the risk of injuries (such as bruising, fractures, etc.) and overlapping (where animals climb over each other or lie partly or completely on top of each other (piling, smothering), with the potential to cause both scratch-type injuries and stress) associated with loading density and/or container height, as set out in the EFSA opinion (EFSA, 2022) on the welfare of domestic birds during transport. This summary is supplemented by an in-depth analysis of the literature on this specific topic, including grey literature and, where possible, resources published more recently than the EFSA opinion.

The bibliographical corpus was established by first conducting searches on the Web of Science™(WOS) and SCOPUS platforms using the following search parameters:

1) ('loading densit*' OR 'stocking densit*' OR 'densit*' OR 'space allowance*' OR 'surface*') AND 'transport' AND ('welfare' OR 'well-being' OR 'injur*' OR 'wound*' OR 'fall*' OR 'bruise*' OR 'stress*' OR 'behaviour' OR 'behaviour' OR 'piling up' OR 'huddling' OR 'smothering') AND ('domestic bird*' OR 'poultry' OR 'broiler*' OR 'chicken*' OR 'duck*' OR 'turkey*' OR 'goose*' OR 'quail*' OR 'guinea fowl' OR 'pullet*' OR 'chick*' OR 'laying hens')

To ensure that all the species to be covered by the present opinion were included, a second search was conducted targeting less-studied species. This search used the parameters developed by the EFSA to obtain the maximum number of relevant results:

2) ('duck*' OR 'geese' OR 'quail*' OR 'turkey*' OR 'game bird*') AND ('transport*') AND ('welfare')

The results obtained from these searches were sorted to remove duplicates and articles already cited in the EFSA opinion. Relevant experimental articles were then selected (by title, keywords and abstracts).

From the 417 documents obtained in the searches, 191 titles were selected. These included 31 review articles or chapters in books which were then removed from the corpus. The selected titles contained references to a further 9 articles that were deemed relevant to the subject matter of this report and were added to the corpus.

In total, the bibliographical corpus thus comprised **169** documents. Of these, **16** were experimental studies comparing different loading densities in containers and **4** were studies on container heights, and are discussed in the detailed analysis of the literature below (see *Section 3.2*).

2 Loading densities in containers and container heights

Loading density in this report refers specifically to the live weight of poultry in a transport container, expressed in kg/cm², while a space allowance represents the relationship between space and an animal in the opposite way, and is expressed in cm²/animal or cm²/kg. The present report refers to both loading densities and to space allowances, as appropriate. In particular, the existing and proposed EU regulations are expressed in terms of the space allowance rather than loading density. Accordingly, in this report, 'space allowance' is always used when referring to these texts.

It should be noted that the method used to calculate the space allowance for poultry differs slightly from that for other domestic animals. In general, as for most other animals, an allometric equation is used that incorporates the animal's weight as a proxy for the volume required for an animal of a particular body shape. However, in the case of poultry, planimetric measurements have been recommended in the literature for some categories of bird. This is because well-feathered birds have greater space needs than their weight would suggest. As a result, 'space allowance' can express two different calculations.

2.1 Current practices

Unlike other species, poultry (other than game birds) are generally transported on short journeys. The data from TRACES show that the majority of journey durations (as opposed to transport durations, which include phases other than the journey itself) are under 4 hours (EFSA, 2022). However, it is important to note that the total time spent by birds in transport containers can be doubled by waiting times (particularly at the abattoir). *Table 1* provides a summary of key features of the transport of poultry (excluding game birds) in France.

With regard to game birds, two particular points should be noted. First, the EFSA opinion (EFSA, 2022) notes far longer journey and transport durations for these species than for other poultry – with journey durations between 12 and 15 hours for pheasants and partridges [and transport durations of up to 20 hours]. Second, game birds are wild species (i.e., non-domesticated) and are therefore more sensitive to transport-related stress (Voslářová et al., 2006). In a study comparing the effects of two container loading densities on pheasant behaviour, Voslářová et al. (2006) have recommended a lower loading density (i.e. a higher space allowance) than that proposed in the regulation.

Table 1. Key features of the transport of domesticated poultry in France (adapted from Dusanter et al., 2003)

Abbreviations: F: Females, M: Males.

	Standard chicken	Premium label chicken	Standard turkey	Lean duck	Fatty duck
Average weight (kg)	1.9	2.2	F: 5.8; M: 11	F: 2.5; M: 4.5	4.5
Time taken to catch the animals	3 hours 15 minutes	2 hours 30 minutes	4 hours 30 minutes	3 hours 45 minutes	1 hour 30 minutes
Type of container (most commonly used, measurements in **cm**)	Containers with drawers (76 x 116)	Loose crates (59 x 79)	Containers with drawers (250 x 117)	Loose crates (59 x 79)	Loose crates (59 x 79)
Loading density (number of birds/container)	Variable	10-12	F: 26; M: 13	F: 12-14; M: 7	4
Loading density (estimated **kg/m²**)	Cages: 40-57 Crates: 71	47-57	F: 50; M: 50-70	F: 65; M: 67	3.9
Mean distance (km)	75				
Mean journey duration	1 hour 20 minutes				
Maximum distance (km)	225	135	272	180	160
Maximum duration (hours)	3 hours	2 hours 20 minutes	4 hours 25 minutes	2 hours 35 minutes	2 hours 30 minutes
Mean waiting time*	2 hours 10 minutes	3 hours 40 minutes	2 hours	2 hours 10 minutes	1 hour 30 minutes
Maximum waiting time*	5 hours 15 minutes	6 hours 20 minutes	3 hours 40 minutes	5 hours 30 minutes	4 hours

* Waiting time for birds between the unloading of the first container from the vehicle and the slaughter of the last bird

2.2 Current regulations

2.2.1 Floor space allowance during transport

Council Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97 specifies, in Annex I, Chapter VII, Part E, the minimum space allowances for poultry transported in containers. These space allowances are set out in *Table 2*.

Table 2. Required space allowances for the transport of poultry by road, according to the current regulations (Regulation No.1/2005)

Category	Minimum floor space allowance
Poultry weighing less than 1.6 kg	180-200 cm²/kg
Poultry weighing 1.6 kg to less than 3 kg	160 cm²/kg
Poultry weighing 3 kg to less than 5 kg	115 cm²/kg
Poultry weighing more than 5 kg	105 cm²/kg

2.2.2 Height of transport containers

Current regulations specify ‘sufficient height’ without providing a minimum or maximum height of containers to be used for transporting poultry.

2.3 Proposed regulation

2.3.1 Floor space allowance

Chapter VII (Clause 3) of Annex 1 to the Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the protection of animals during transport and related operations, amending Council Regulation (EC) No 1255/97 and repealing Council Regulation (EC) No 1/2005 (European Commission 2023), available here, suggests that the space allowance per animal should be calculated according to the following allometric equation:

$$A = k \times W^{2/3}$$

where A = area per animal (in cm^2 for transport of birds), W = live weight (in kg), and k is the constant (k-value) specific to species or category (taken from Petherick & Phillips, 2009). The k-value for poultry is **290** (value recommended by the EFSA (EFSA, 2022)).

A summary of the floor space allowances per bird and per kg suggested by the proposed regulation is provided in *Table 3*.

Table 3. Space allowances for road transport of poultry, according to the proposed regulation

Live weight (kg)	0.25	1.5	2	2.5	3	3.5	4	4.5	5	8.6	15.9	22.5
Space allowance (cm²/animal)		380	460	534	603	669	731	790	848			
Space allowance (cm²/kg)	458*	254	230	214	201	191	183	176	170	143*	116*	104*
Category*	Quails	Pullets**, Game birds**	Laying hens (poor feather cover), Laying hens (average feather cover)***							Turkeys		
			Breeder layers									
			Broilers									
			Ducks									
			Geese									

* This information is taken from EFSA, (EFSA, 2022 -Tables 10 & 11).
** For these categories, the EFSA recommends using a planimetric equation[4], giving an allowance of 310 cm²/kg (EFSA, 2022 - Table 11).
*** For this category, the EFSA recommends using a planimetric equation[4], giving an allowance of 268 cm²/kg (EFSA, 2022 - Table 11).

2.3.2 Height of transport containers

Chapter III (Clause 6.4) of Annex I to the Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the protection of animals during transport and related operations, amending Council Regulation (EC) No 1255/97 and repealing Council Regulation (EC) No 1/2005 does not propose specific height allowances, specifying instead that 'for domestic birds the height of the container shall be such that the comb or head does not touch the ceiling when birds sit with their head and neck in a natural posture or when they change position' (Annex I, European Commission, 2023).

[4] Based on measurements obtained using overhead photography, giving a more appropriate estimate of space needs for these categories.

3 Literature review on the risks of injury and overlapping in relation to the space available (floor space and container height)

3.1 The EFSA's view

The EFSA takes the view that the space available to animals, including both the floor areas and heights of containers, plays a key role in welfare during transport. The main reasons it gives for this are that insufficient space leads to:

1) a higher risk of **heat stress**, which can lead to death,
2) **restriction of movement** (inability to express natural postures comfortably), which can cause frustration, discomfort, fear and even pain during transport, thus generating negative affective states that persist until the birds are unloaded.

Restriction of movement is a welfare consequence inherent to the transport domestic birds confined in containers (EFSA, 2022). Its negative effect on welfare cannot therefore be prevented, only mitigated.

3.1.1 Floor space

The EFSA considers that the floor area available during transport is a determining factor for the welfare of poultry and it specifies minimum floor space allowances in cm²/kg using two methods of calculation. These are:

1) **the allometric equation** ($A = k \times W^{2/3}$) for most bird categories (see *Table 3*), with a k-value of **290** to reduce the negative consequences associated with, e.g., restriction of movement, heat stress and sensory overstimulation (k-value based on Baxter, 1992).
2) **Planimetric measurements**[5] for game birds, pullets and well feathered laying hens weighing less than 2 kg to take account of their particular need for additional space.

The EFSA's minimum space requirements take into consideration the basic biological functions of poultry during transport, including:

1) the floor area that would be required for all birds in a container to stand or sit comfortably at the same time (which determines the value of 290 for the constant k in the allometric equation)

[5] Based on measurements obtained by overhead photography (Ellerbrock & Knierim, 2002; Giersberg et al., 2016; Mench & Blatchford, 2014a; Spindler et al., 2013, 2016) .

2) the ability of the animals to move around and change position to adjust to the hazards of transport (temperature, visual stimuli, etc.)
3) the ability of the animals to thermoregulate (by huddling together or extending their wings away from their bodies, etc.)

However, as the EFSA points out, the allometric equation **assumes that all domestic birds have a similar shape**. Therefore, it does not allow **for an exact calculation** of the area covered by a bird when sitting or changing position, but rather provides **estimates** of space requirements.

With regard to the risk of injuries, EFSA cites studies that found that an increase in floor space allowance per animal was accompanied by a decrease in the number of animals found dead on arrival (DOA) (mainly on journeys during heat waves) but also by an increase in the number of injuries observed on arrival. However, as the EFSA experts point out, the methods used in these studies make it impossible to establish whether such injuries were due to falls or overlapping caused by the increase in available space. The EFSA therefore concludes that **a balance must be found between** the known impacts on poultry welfare of **restriction of movement and reducing the risk of injuries. The EFSA calculates its recommendations for space allowances for each category (i.e. by type of poultry, weight and life stage) taking the lowest live weight of the range as a precautionary principle.**

Last, the EFSA emphasises the need for research on links between the risk of injuries and increased space allowances for poultry transported in containers.

3.1.2 Height of transport containers

The EFSA takes the view that insufficient container height increases restriction of movement and the risks of injury and heat stress due to poor air circulation. It recommends a minimum height that will allow birds to:

1) adopt **natural sitting postures with their heads extended (without their combs or heads touching the ceiling)**;
2) **move and change** posture within the container.

However, the container height should not allow birds to stand in a natural position. The heights detailed in the EFSA opinion are set out in *Table 4*.

Table 4. Current commercial cage heights and EFSA expert recommendations for minimum heights, by domestic bird category (see EFSA, 2022 - p.51)

Category	Bird weight (kg)	Current commercial container heights (cm)	**Minimum heights recommended by the EFSA (cm)**
Pullets	≤ 1.5	23–25.5	**25**
Laying hens	≤ 2	23–25.5	**25***
Broiler chickens	≤ 3.4	23–25.5	**23**
	> 3.4	23–25.5	**25**
Turkeys	11 ≤ and ≥ 13	31–42	**40****
	14 ≤ and ≥19	31–42	**45****

In their study , Mench & Blatchford (2014) note that a minimum height of **35 cm is necessary for a natural standing posture.*

Recommendation made by the EURCAW-Poultry-SFA (2022): Query Q2E-EURCAW-Poultry-SFA-2022-001: What are the heights of transport crates that will mitigate restriction of movement in turkeys of different weights? Estimates based on 43 turkeys weighing between 11.5 kg and 19.2 kg.* ***Recommended heights are based on the maximum height of the turkeys in each weight category.

With regard to the risk of injury, the EFSA reports that very few articles have studied the risk of injuries due to falls and overlapping when the height of transport containers is increased. Of the references cited, several reported an increase in injuries[6] when birds were able to stand during transport. However, the EFSA points out that these results are based on post-mortem analysis and therefore do not clearly identify the cause of these injuries (loading, unloading, falls during transport, etc.).

Concerning the floor space allowance, the EFSA concludes that **a balance must be struck between** the known impacts on poultry welfare of **restriction of movement, and reducing the risk of injuries.** In addition, to ensure good air circulation above the birds while they are sitting, account must be taken of the significant variability in weight between individuals within the same category. The EFSA therefore bases its recommendations on **the maximum height of the birds assessed in each category** in the selection of container heights.

Last, the EFSA stresses the need for research on links between the risk of injuries and an increased height allowance for poultry transported in containers.

EFSA recommendations on research:

The EFSA identifies a need for further research to i) determine bird preferences for both floor space and head height during transport in containers, ii) better understand the effect of the space allowance [floor space and container height] on, among other things, bird behaviours, risk of injuries and thermal stress for different species and categories of poultry. It also identifies iii) a need for studies to identify how and when poultry injuries occur during transport (e.g. at different transport stages such as loading and unloading, the journey itself, etc.).

3.2 Additional information from the corpus

Table 5 and *Table 6* summarise the results of the 20 experimental studies in the corpus. Each row summarises the data from a single study (published between 2006 and 2025) containing an assessment of the effects of loading densities (or space allowances) inside transport containers and/or container heights. The studies used a variety of indicators to investigate different poultry types (broiler chickens, quails, ducks, turkeys and pheasants – excluding chicks). Only references not previously discussed in the EFSA opinion are included. **The conclusions reported in the last column of each table are those of the authors of the article in question.**

[6] For details of the analysis in these publications, see EFSA (2022) pp. 46-47

3.2.1 Floor space

Table 5 and *Table 6* show the impacts of loading density (expressed as space allowances) relating to floor space described in individual studies. These were calculated on the basis of the information contained in the articles and the average weight of the animals studied. Their results are compared with the space allowances set out in the proposed and current regulations. It should be noted that the impact of loading density on poultry behaviours was not investigated in the studies shown in this table.

Table 5. Summary of the results of experimental studies on the impacts of loading density (floor space allowances) and container heights for poultry during transport on their risk of overlapping and injuries, through analysis of physiology and meat quality.

Space allowances shown in green boxes fulfil the requirements of the new regulatory proposal, those in blue boxes meet current regulatory requirements, and those in red boxes are lower than current regulatory requirements. Conclusion column: '+' the study concludes that there is an improvement in the welfare of the poultry with an increase in the space allowance (decrease in loading density) / '=' the study concludes that an increase in the space allowance (decrease in loading density) has no significant negative impact on welfare / '-' the study concludes that there is a deterioration in the welfare of the animals with an increase in the space allowance (decrease in loading density). Unless otherwise indicated, all results are significant. Abbreviations/terms: NS: not significant. []°: concentration, AST: aspartate aminotransferase, ALAT: alanine aminotransferase, BHB: beta-hydroxy-butyrate, CK: creatine kinase, CPK: creatine phosphokinase, DAU: Dead At Unloading, DOA: Dead On Arrival (number of animals dead on arrival), Fitness: absence of emaciation, pododermatitis, disease, physical defects and cachexia, H/L: ratio of heterophils to lymphocytes, HSP 70: Heat Shock Proteins 70 kDA, LDH: lactate dehydrogenase, MCH: Mean Corpuscular Haemoglobin, MCHC: Mean Corpuscular Haemoglobin Concentration, MCV: Mean Corpuscular Volume, NK: Not Known, NEFA: Non-esterified fatty acids, PCV: Packed Cell Volume (or haematocrit), T_3: Triiodothyronine, T_4: Thyroxine, TG: Triglycerides, TBARS: Thiobarbituric Acid Reactive Substances (estimate of plasma lipid peroxidation), L: lightness, a*: red, b*: yellow, c: Chroma, h: hue, pH_{mus}: muscle pH, pm: post-mortem, WHC: Water Holding Capacity. '/': parameter not studied/mentioned in the article, 'X': interaction between two variables*

Type of poultry	Reference	Breed and age of animals	Average weight (kg)	Catching and handling method	Journey duration (min) and/or time spent in containers Season/time of transport	Minimum space allowance to be respected according to the regulatory proposal (cm²/bird & cm²/kg)	Current regulatory minimum allowance (EU) (cm²/kg)	Space allowances studied (cm²/bird & cm²/kg)								Container heights studied (cm)	Injuries (discussed in relation to loading density)	Physiology / Meat quality (discussed in relation to loading density)	Conclusion of the authors of the study
Broiler chickens	Pirompud et al., 2023	Broiler chickens Age groups (in days): 40–43, 44–47, 48–51, 52–55 and 56–71	~3	Around wings and chest while upright (2 at a time)	/ Time kept in containers after journey: 30-120 Winter, summer or rainy season; night, morning and daytime	603 cm²/bird 201 cm²/kg	115	**~ 972 cm²/bird ~316 cm²/kg**						**389 cm²/bird 128 cm²/kg**		31	⇧ Density ⇩ **Bruising** (larger than 1/3 breast area and leg, larger than 2 cm² for wings, bruises counted as 1 per carcass) (%)	⇧ Density ⇧ DOA (%), Carcass condemnation (%)	+
	Szőllősi et al., 2025	Broiler chickens (Ross 308)	3.2 ± 0.035	By one leg, inverted	Transport: mean duration = 22.43; median duration = 24 + Catching and loading duration: 45 + Time kept in containers after journey: mean duration = 173.29; median duration = 158 Spring	630 cm²/bird 197 cm²/kg	115		**649-675 cm²/bird 203-211 cm²/kg**		**511-519 cm²/bird 159-162 cm²/kg**					27	⇧ Density ⇩ **Wing injuries** (% of birds), **Bruising** or haematomas (% of birds) **Thigh injuries: NS**	⇧ Density ⇧ DOA (%), Carcass condemnation (%)	- *NB the reference space allowance used for heavyweight broilers in the study was 160 cm²/kg. In Regulation No. 1/2005, this allowance applies to lighter birds, < 3 kg*
	Jacobs et al., 2017	Fast-growing broiler chickens (Ross 308) Age: 41 days	2.6	Around chest in the correct position, one at a time	45 + Total time spent in containers (including journey): 14 – 18 hours Winter	548 cm²/bird 211 cm²/kg	160			**572 cm²/bird 220 cm²/kg**		**494 cm²/bird 190 cm²/kg**	**416 cm²/bird 160 cm²/kg**			25.5		⇧ Density ⇧ []° Plasma glucose, ambient temperature (no pValue) Lowest and highest densities ⇩ Fitness levels ⇧[]° Plasma cortisol **Plasma variables**: []° Cortisol, []° Lactate, []° TBARS: **NS**	Loading density x fitness interaction Medium density
	Hussnain et al., 2020a				/ Three distances: 80 km, 160 km and 240 km Autumn											30	**Bruising** (wings, chest, legs): NS **Injuries**: NS	⇧ Density ⇧ Weight loss ⇩ Total serum protein Medium density ⇧ Thigh weight (% carcass) ⇩ Back weight (% carcass) Highest density ⇧ DOA, Catalase activity (X length of journey) **Serum & body condition variables**: []° Glucose, []° Uric acid, []° T3, []° T4: **NS**	+
	Hussnain et al., 2020b	Broiler chickens (Ross-308) Age: 35 days	1.9-2.05	/	/ Three distances: 80 km, 160 km and 240 km Winter	445-468 cm²/bird 234-228 cm²/kg	160				**500 cm²/bird 263–244 cm²/kg**		**420 cm²/bird 221-205 cm²/kg**		**330 cm²/bird 171-161 cm²/kg**	30	**Injuries** (% of birds injured): / **Bruising** (chest, wings, legs) (% injured birds): NS	⇧ Density ⇧ Breast weight (% carcass), []° serum: Glucose ⇩ []° T4, TG Highest density ⇩ Weight loss ⇧ Rectal temperature **DOA, Serum & body condition variables** []° Cortisol, []° T3, []° Uric acid, Catalase activity, []° Total serum proteins, []° Albumin; Carcass weight (with neck, no giblets) (%); Wing and drumstick weight; Abdominal fat ratio (abdominal fat weight/live weight) (%); Breast fat ratio (abdominal fat weight/carcass weight) (%): **NS**	- *In terms of economic loss rather than chicken welfare*
	Hussnain et al., 2020c				/ Three distances: 80 km, 160 km and 240 km Summer (hot and humid)													⇧ Density ⇧ Thawing loss (%), Cooking losses (X length of journey) (%), shear force, L* **Meat quality** pH_{mus} , a*, b*, c, h; Cooking losses (%): Marinade uptake, Marinade retention: **NS**	+
	Saraiva et al., 2020	Fast-growing broiler chickens (Ross 308 and Cobb) Age: 30-42 days	1.4-2.4	Manual	Transport duration 22–184 Mean duration: 72 Median duration: 59 Spring	363-520 cm²/bird 260-216 cm²/kg	[180-200] - 160					**~ 443 cm²/bird 233 cm²/kg**			**~ 329 cm²/bird 173 cm²/kg**	/	⇧ Density (cm²/kg) ⇩ **Bruising** (breast, wings, legs) ⇧ Number of birds/lorry ⇧ **Bruising** (breast, wings, legs) ⇧ **Transport duration** **Bruising** (breast, wings, legs): **NS**	⇧ **Transport duration** ⇧ DOA (%)	- *'bruises did not increase with transport duration, indicating that bruises were more likely to have occurred on farms, during catching, crating and loading.' (p.6)*

Type of poultry	References	Breed and age of animals	Average weight (kg)	Catching and handling method	Transport duration (min) and/or time spent in containers Season/time of transport	Minimum space allowance to be respected according to the regulatory proposal (cm²/bird & cm²/kg)	Current minimum regulatory space allowance (EU) (cm²/kg)	Space allowances studied (EU) (cm²/bird & cm²/kg)	Container heights studied (cm)	Injuries	Physiology / Meat quality	Conclusion
Broiler chickens	Delezie et al., 2007	Broiler chickens (Ross): Age: 42-43 days	/ *Average slaughter weight for the breed: ~3-5*	By one leg, inverted, 4 - 6 birds at a time	Transport: 90 + Time kept in containers after journey: 60 Season: NK	603-848 cm²/bird 201-170 cm²/kg	115	**575 cm²/bird 192–115 cm²/kg** **350 cm²/bird 117-70 cm²/kg**	/		**Highest density** ⇧ Rectal temperature; []° plasma: Cortisol, Uric acid; NEFA, HSP70; WHC (density X feed) ⇩ [] °plasma: T_3 (density X feed), T_4 , TG **Plasma, haematological & body condition variables:** []° TG, []° Glucose, []° Lactate, pH_{mus} , []° CK; PCV, TBARS; Weight loss: **NS**	+
	Kittelsen et al., 2018	Fast-growing broiler chickens (Ross 308) Age: 33 days Slow-growing broiler chickens (Hubbard JA 787) Age: 44 days	2 2.3	By two legs, inverted (LEG) or Under abdomen, upright (UPRIGHT)	/	460 cm²/bird 230 cm²/kg 505 cm²/bird 220 cm²/kg	160	**444 cm²/bird 220 cm²/kg**	/	Leg fractures, birds on their backs in drawers: **None observed** **Effects of broiler strain**: ⇧ Wing fractures/dislocations/detachment of epiphyseal plates with visible bleeding for Ross 308 strain **Effects of catching methods**: ⇧ Wing fractures/dislocations/detachment of epiphyseal plates with visible bleeding for the LEG method	**/**	/
	Bedáňová et al., 2006	Fast-growing broiler chickens (Ross 308) Age: 42 days	3.05	/	/ Time kept in containers: 120 Season: NK	669 cm²/bird 191 cm²/kg	115	**402 cm²/bird 115 cm²/kg** **368 cm²/bird 105 cm²/kg**	25		**[]° Haematocrit**: **NS** **Haematological variables**: **NS** **⇧ Density** ⇧ []° Haemoglobin, MCV, MCH, []° MCHC ⇩ []° erythrocytes	+
	Yu et al., 2024	Fast-growing broiler chickens (Ross 308) Age: 35 days Sex: male	1.9 ± 0.017 1.8 ± 0.017	By chest, upright (UPRIGHT)	40 Summer 40 Winter	429 cm²/bird 238 cm²/kg	160	**390 cm²/bird 217 cm²/kg** **310 cm²/bird 172 cm²/kg** **260 cm²/bird 144 cm²/kg**	26	/	**Medium density** ⇩ Weight loss ⇧ []° Lactate **Highest density** ⇧ Respiratory rate Body **condition** and **meat quality variables**: Carcass weight (with neck, no giblets) (%), breast weight (g); pHmus, L*, a*, b*, WHC (%), Cooking losses (%): **NS** **⇧ Density X High temperature** ⇧ Weight loss; []° plasma: Cortisol, Glucose; Respiratory rate **⇧ Density X Low temperature** ⇩ Weight loss; []° plasma: Cortisol, Glucose	Manage density-temperature interactions. Medium density advised regardless of season
	Whiting et al., 2007	Broiler chickens 198 loads studied (Total number of chickens: 1,090,733)*	1.9 (standard error: 0.146)	/	Average duration: 94, maximum duration: 360 (standard deviation = 68) + Average waiting time at abattoir: 240 Spring - summer	429 cm²/bird 238 cm²/kg	160		/		⇧ **DAU (%)** (deaths at unloading) ⇧ Density*	+

**In this study, chickens were divided into two groups based on Dead at Unloading (DAU): Number of loads for which DAU > 40 = 18 and Number of loads for which DAU < 40 = 180. Loads for which DAU > 40 had, among other variables, a significantly higher stocking density within the containers than other loads.*

Type of poultry	Reference	Breed and age of animals	Average weight (kg)	Catching and handling method	Transport duration (min) and/or time spent in containers Season/time of transport	Minimum space allowance to be respected according to the regulatory proposal (cm^2/bird & cm^2/kg)	Current minimum regulatory space allowance (EU) (cm^2/kg)	Space allowances studied (cm^2/bird & cm^2/kg)				Container heights studied (cm)	Injuries	Physiology / Meat quality	Conclusion
Quails	Silva et al., 2023	European breeding quails (*Coturnix coturnix*) Age: 365 days (end of breeding cycle) Sex: male and female	0.345	/	90 Season: NK	458* cm^2/kg	180-200	**182 cm^2/bird 527 cm^2/kg**	**143 cm^2/bird 414 cm^2/kg**	**118 cm^2/bird 341 cm^2/kg**	**100 cm^2/bird 290 cm^2/kg**	24	/	⇧ **Density** ⇧ DOA (%) **Medium densities** ⇧ Hot and cold carcass weight and L* **Plasma variables & meat quality**: []° Corticosterone, []° Cortisol, []° Glucose, []° Uric acid; pHmus, a*, b*, WHC (%), Cooking loss, Water retention (%): **NS**	+
Ducks	Jainonthee et al., 2025a	Meat duck Age: 42 days	3.1 ± 0.31	/	Average duration: 108 + Average time spent in containers after transport: 112 Three times: night, morning and daytime Summer, rainy season and winter	603-669 cm^2/bird 191-201 cm^2/kg	115	***highest allowance*** 960 cm^2/bird 419 cm^2/kg	***lowest allowance*** 770 cm^2/bird 226 cm^2/kg			/	/	⇧ **Number of ducks per load** ⇧ DOA (%)	/
	Jainonthee et al., 2025b	Meat duck (Cherry Valley x *Grimaud Frères*) Age: 42 days	3.1 ± 0.34	Manual	Average duration: 118 + Average time spent in containers after journey: 96 Three times: night, morning and daytime Summer, rainy season and winter	362 -480 cm^2/bird 603-669 cm^2/bird 191-201 cm^2/kg	115	***highest allowance*** 960 cm^2/bird 419 cm^2/kg	***lowest allowance*** 770 cm^2/bird 226 cm^2/kg			31	/	/	DOA affected by loading density
Game	Voslářová et al., 2006	Pheasant (*Phasianus colchicus*) Sex: males and females Age: 9 weeks	/ *Average slaughter weight of strain: 0.800-1.5*	/	240 Season: NK	250–380 cm^2/bird	180–200 cm^2/kg	cm^2/bird not specified 290 cm^2/kg	cm^2/bird not specified 195 cm^2/kg			/	/	⇧ **Density** ⇧ MCV ⇩ Erythrocyte count and H/L ratio	+ Recommendation: minimum space allowance 290 cm^2/kg

Of the 16 selected articles addressing the effects of loading density in transport containers on various welfare-related parameters in poultry (broilers, quails, ducks and certain game birds only), seven concluded that a reduction in loading density (increased space allowance) had a beneficial effect, three concluded that it had a negative effect, and two recommended a medium loading density to take into account interactions with other risk factors (temperature and the birds' state of health). Last, three studies considered overall loading density (i.e., the number of containers per lorry), of which one concluded that the number of animals DOA increased in line with loading density, while the other two drew no conclusions concerning the effects on animal welfare (*Table 5*).

Those studies that considered lower density to have beneficial effects highlighted two main outcomes: reduced stress in the birds and lower temperatures (particularly inside the containers, Bedáňová et al., 2006; Delezie et al., 2007; Hussnain et al., 2020a, Hussnain et al., 2020c; Voslářová et al., 2006). However, several of these studies reported greater weight loss during transport at the lowest densities, which could be explained by increased movement of the birds (Hussnain et al., 2020a; Silva et al., 2023).

Only two studies reported a significant difference in the number of injuries related to loading density in containers (observed mainly in the percentage of bruises on the breast, legs and wings, Pirompud et al., 2023; Silva et al., 2023). The conclusions of these two studies differed, though. The latter study concluded that a reduction in loading density (increased space allowance) in containers had a negative effect on the birds (Silva et al., 2023), whereas the authors of the former concluded that, despite an increase in the percentage of injuries, the overall effect of a reduction in loading density (increased space allowance) was positive, citing in particular the significantly lower DOA numbers (Pirompud et al., 2023).

In the two studies to conclude that a medium loading density is most suitable, the authors observed that extreme densities (the lowest or highest) combined with extreme temperatures or individual birds' poor physiological condition increased the risk of stress. Hence, at low temperatures, low loading density would increase the risk of cold stress and, conversely, high loading density combined with high temperatures would increase the risk of heat stress (Jacobs et al., 2017; Yu et al., 2024).

Last, three studies concluded that an increased space allowance per bird would have negative consequences (Hussnain et al., 2020b; Saraiva et al., 2020; Szőllősi et al., 2025). Of these, two recorded increased mortality during transport, but only one established a direct causal link between loading density and mortality during transport (Szőllősi et al., 2025). However, this study was exceptional in that the journey duration was only 24 minutes, with an average total time spent in the containers (from loading to unloading) of 227 minutes. The relatively short duration of the journey compared with the duration of other stages of transport suggests that the journey itself may have had little effect compared with the other stages (as shown, for example, by Kurganov et al., 2021). In the second study to record increased DOA numbers at lower densities, the authors reported specifically that 'bruises did not increase with transport duration indicating that bruises were more likely to have occurred on farms during catching, crating and loading' (Saraiva et al., 2020, p.6). Last, the third study (Hussnain et al., 2020b) concentrated more specifically on carcass quality and economic losses rather than on the welfare of the birds, drawing no direct conclusions concerning animal welfare.

In conclusion:

The literature reviewed in the present report does not provide an answer to the question posed[7] for laying hens, turkeys, geese and other game birds, as no studies compared the allowances in the regulatory proposal with lower densities. **Some scientific studies did, nevertheless, highlight an increase in the number of injuries (bruises) at lower container loading density** for broiler chickens**.** However, the data in these studies were based on observations on slaughter lines, not on direct observations of the birds during transport, making it impossible to draw conclusions regarding the causes of these injuries. **Indeed, studies tend to agree that the main factors to affect the risk of injury are the catching and crating methods employed, rather than the space allowance per bird during transport** (Kittelsen et al., 2018; Unterholzner et al., 2025).

Last, **studies tend to show that a reduction in loading density in transport containers reduces DOA numbers** (for broilers, quails and ducks), **particularly when temperatures are high**. Ultimately, when seeking to ensure that transport conditions are best suited to the birds, the most relevant action would appear to be to take account of the interactions between temperature, health status and loading density within the containers[8].

3.2.2 Height of transport containers

Table 6 sets out the impacts of container height for each weight and type of bird described in individual studies. The studies identified in the search that addressed this question discussed male and female turkeys only. The conclusions reported in the last column of the table are those of the authors of the article in question.

Given that falls and overlapping were rarely directly observed in the studies reviewed, the FRCAW took the decision to extend the present analysis to all observed behaviours and to some meat quality parameters, as these could provide indirect information relating not only to any injuries observed on the carcasses but also to the stress experienced by the birds during transport. To supplement this analysis, physiological indicators were also taken into consideration, furnishing additional information on the stress undergone during transport.

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[7] 'Is it the case that [poultry] transported by road at the densities and heights set out in the proposed regulatory revision to Regulation 1/2005 are more at risk of [overlapping] and/or injuring themselves than poultry transported by road at the densities and heights laid down in the current Regulation (Regulation 1/2005)?'

[8] See *4.2 Factors increasing the risks of overlapping and/or injury during the transport of poultry*

Table 6. Summary of the results of experimental studies on the impact of the height of poultry transport containers on the risks of overlapping and injury, analysing behaviour, physiology and meat quality.

Unless otherwise stated, all results shown are significant. NS: not significant. Abbreviations: []°: concentration, AST: aspartate aminotransferase, ALAT: alanine aminotransferase, CK: creatine kinase, H/L: heterophil/lymphocyte ratio, LDH: lactate dehydrogenase, PCV: Packed Cell Volume (or haematocrit), TG: triglycerides, L: lightness, a*: red, b*: yellow, c: chroma, h: hue, pHmus: muscle pH. '/': parameter not studied/mentioned in the article, 'X': interaction between two variables.*

Type of poultry	References	Animal details	Transport duration (min) and/or time spent in containers Season	Method of catching	Average weight (kg)	Heights* studied (cm)			Behaviours (including overlapping)	Injuries	Physiology / Meat quality	Conclusion
Turkeys	Di Martino et al., 2017	Female turkeys	76 ± 4 Season: NK	Manual	11 ± 0.5	77		38.5	**Upper height** ⇩ Sitting/lying down ⇧ Loss of balance, wing flapping **Overlapping observed: 6% of birds** (behaviour impossible at lower height)*; Standing with legs bent ('low standing position'): 0% of birds* **Both heights** Remained standing: 36% of birds **Lower height** Standing with legs bent ('low standing position'): 5% of birds **Postures & behaviours:** Sitting/lying down, sitting, standing, standing with legs bent ('low standing position'); Turning: **NS** Preening, stretching, panting: **None observed** Stepping, rising attempts: **too few observations**	**Injuries** (scratches, fractures, haematomas): **None observed**	**Upper height** ⇩ []° Total protein **Blood variables:** []° ALT, []° AST, []° LDH, []° CK, []° TG, []° PCV, []° Corticosterone, []° H/L, []° Uric acid, []° Lactate: **NS**	Mixed effects: Reduces stress but increases risk of injury
	Poursaberi et al., 2009	Male turkeys Age: 18 weeks	/ Season: NK	/	/	90		40	**Lower height** Unable to stand upright **Postures & behaviours:** Lying, standing; Turning, wing-flapping: **not compared**	/	/	/
	Wichman et al., 2010	White turkeys (Nicolas 300) Age: 17 weeks	180 Season: NK	/	13.5 - 14.5.	90	55	40	**Lowest height** ⇩ Standing ⇧ Standing with legs bent ('low standing position'), Lying, rising attempts; ⇩ Stepping, turning **Postures:** Sitting: **NS**	/	**Intermediate height** ⇩ []° Lactate **Blood variables:** []° CK , H/L, []° ASAT: **NS**	Medium crate height is the most appropriate.
	Wichman et al., 2012	White turkeys (Nicolas 300), male Age: 120-133 days	40-90 + Lairage time in cages: 120-220 Total time: 4-7 hours Autumn	/	Carcass weight 11.0 - 12.6	75		40	**Overlapping:** **Lower height: 3 times; Upper height**: 1 time **Lower height** ⇧ Panting, lying ⇩ 'Unusual position' (no p Value) *Standing: behaviour not possible* **Both heights** Mainly lying **Height x Waiting time in lairage** ⇧ Panting for lower height only; standing for upper height only **Postures** (sitting): **NS**	**Upper height** ⇧ Scratches on back **Injuries:** Bruises on rump, red bruise on wings, wing fractures: **NS**	**Meat quality:** pHmus, L*, []° Glycogen, []° Lactate: **NS**	Mixed effects

**Reminder: the minimum height requirement to be observed according to the proposed regulation must be 'such that the comb or head does not touch the ceiling when birds sit with their head and neck in a natural posture or when they change position'. The current (EU) regulation does not impose a minimum height for containers.*

Of the four studies to consider the impact of container height on various parameters related to bird welfare, only two directly examined the number of injuries and overlapping (Di Martino et al., 2017; Wichman et al., 2012). In the first study, the lower height did not allow overlapping to occur, so a direct comparison was not possible. However, overlapping behaviours were observed in 6% of turkeys in the taller containers (Di Martino et al., 2017). In the second study, both selected container heights allowed male turkeys to overlap. Although the study did not ascribe a significance to this effect, because there were too few cases, the authors observed more overlapping in crates 40 cm high (three instances of overlapping) than in crates 90 cm high (only one instance of overlapping observed, Wichman et al., 2012).

With regard to injuries, two studies compared their number in relation to the height of the containers (Di Martino et al., 2017; Wichman et al., 2012). In the first study, no injuries were observed (Di Martino et al., 2017), while in the second, only the number of scratches on the back was significantly higher in turkeys transported in the taller containers (Wichman et al., 2012).

Last, regarding the impact of container height on stress in the birds (measured indirectly via blood tests and/or meat quality), few effects were found. However, where significant differences were found, these involved a decrease in the observed stress markers for birds transported in taller containers (Di Martino et al., 2017; Wichman et al., 2010). This decrease was explained either by the birds' ability to adjust their positions or by a reduction in heat stress (measured by the number of birds panting).

In conclusion:

The literature considered in this expert report does not provide an answer to the question posed[9]. The few available studies, on turkeys, **conclude that a medium container height has a positive impact on the birds' comfort** and agree with the EFSA's recommendations for **a container height that is restrictive enough to prevent birds from climbing on each other but sufficient to allow them to change position and sit with their heads and necks in a natural raised position**. In the three studies analysed, the authors conclude that increasing container heights reduces stress in the birds but increases the risk of injury.

There is, however, **a need for more research** because in all studies but one, which did not address the issue of container height, **injuries were observed on arrival and could not therefore be directly attributed to transport** (*see Conclusion 3.2.1)*. Furthermore, as for loading density based on floor space, a number of **interactions between temperature and container height** have been observed: lower heights foster higher temperatures, and therefore heat stress[10].

Last, **research on other poultry species is also needed, to explore whether and how container height impacts the number of injuries and degree of overlapping during transport.**

[9] Is it the case that [poultry] transported by road at the densities and heights set out in the proposed regulatory revision to Regulation 1/2005 are more at risk of [overlapping] and/or injuring themselves than poultry transported by road at the densities and heights laid down in the current Regulation (Regulation 1/2005)?

[10] See *4.2 Factors increasing the risks of overlapping and/or injury during the transport of poultry*

4 Further analysis and discussion

4.1 Interactions between space allowances (floor area and container height) and stress in poultry during transport

The spatial volume (container floor area and height) available to poultry during transport mainly affects the birds' ability to express behaviours such as posture changes and thermoregulatory behaviours (panting, wing extension, huddling, etc.). The volume of transport containers also has an effect on birds' loss of balance during transport. Injuries and overlapping during poultry transport can be sources of stress. Several studies reported an increase in these markers during bird transport (e.g. in ducks, Bergman et al., 2025, or turkeys, Marques et al., 2016).

The temperature inside the containers is another major factor during transport and can act as a source of thermal stress. Ncho et al. (2025) have reported two types of behavioural adjustment in response to these combined stresses – changes in locomotor activities and the adoption of specific postures (*see Section 4.2.2.3*). By facilitating or preventing certain behaviours, the volume of transport containers has a direct impact on the capacity of poultry to adapt to temperatures beyond their thermoneutral zone.

These stresses (related to restricted movement, overlapping or loss of balance, and temperatures) can be measured indirectly, via physiological responses tested through blood sampling or carcass examination on the slaughter line. However, the direct observation of the birds' behaviour during transport is made difficult (if not impossible) by the very nature of poultry transport accommodation (containers, crates or drawers), preventing conclusions from being drawn on the direct impact of a reduction in loading density per container on the risks of injury or overlapping (EFSA, 2022). Work has nevertheless been carried out by Poursaberi et al., (2009) to test the accuracy of an automatic recognition system for turkey behaviours during transport, concluding that use of this method was feasible to detect and analyse the study's four chosen behaviours: turning, wing flapping, lying and standing. It may therefore be of interest **to develop such systems for the direct assessment of behavioural changes during transport and improve scientific understanding of the effects of space allowances on birds**.

4.2 Factors increasing the risks of overlapping and/or injury during the transport of poultry

Figure 1 provides a summary of the interactions between risk factors for poultry during transport.

4.2.1 Factors that may increase the risk of injury in relation to the space allowance

4.2.1.1 Driving quality

Careful driving of lorries is essential to prevent birds from falling and injuring themselves in containers. Excessive acceleration, deceleration, braking and cornering can cause birds to lose their balance, increasing the risk of falls, injuries and stress (EFSA, 2022; María, 2008).

4.2.1.2 Design of vehicles and transport containers

During transport, poultry experience two different types of movement – one during the loading and unloading of the containers and the other related to the movement of the lorry itself. The risk of injury to the birds is therefore also related to the design, operation and maintenance of all equipment used for loading and unloading (containers, catching devices, forklift trucks, conveyor belts). It should be noted that handling during catching and the loading of the birds into the containers is a particular source of risk in terms of injury to birds (Prescott et al., 2000; Unterholzner et al., 2025).

Furthermore, although the literature does not highlight any connection between lorry design itself and the risk of injuries, a negative impact on poultry can nevertheless arise from design problems. Thus, the experience of vibrations can be a source of motion sickness and discomfort (Warriss et al., 1997) and, in certain types of lorries or even certain locations within the lorry, birds may be exposed to air pollution (exhaust fumes), harsh light (sensory overstimulation) and thermal stress (from heat or cold). It has been shown that sensory overstimulation, such as continuous or sporadic noises of the type produced by lorries (Ncho et al., 2025), can cause a flight response or piling in birds trying to escape the stimuli. To reduce these behaviours, dividers can be incorporated to prevent animals from excessive piling and risking suffocation, or causing the lorry to tilt as the result of uneven weight distribution.

Other studies have highlighted interactions between the loading density of containers in a lorry and its layout. For example, Watts et al., (2011) have shown **interactions between loading density, temperature and moisture in transport vehicles and containers,** concluding that birds should be **kept within their thermoneutral zone to limit the production of additional heat or moisture**. One of the most effective actions to regulate temperature is the organisation of container positions inside the lorry. The risk of heat stress is greater at the front of the lorry (behind the cab) and in the lowermost containers. Consequently, a **calculated adjustment to the total loading density, in particular by leaving containers in these areas empty, offers an effective way of controlling heat stress** (EFSA, 2022). Additionally, thermal stress (whether cold or hot) can induce a flight response in birds or cause them to huddle together (for warmth, for example) or, conversely, to move apart to cool down. **The possibility for birds to be able to express these behaviours depends mainly on the space allowance per animal in the transport containers** (*see Section 4.1).*

Last, other aspects of the physical environment in a lorry can affect overall air circulation and quality and can influence how the various risk factors for poultry welfare interact. These include ventilation type (static or dynamic), the presence of tarpaulins on the sides (to restrict entry of light or rain) and the use of spacers to improve air circulation between containers. However, a study by Pinheiro et al.

(2021) of the effect on ventilation patterns of spacers between crates found that the internal ventilation within the crates did not change. These results highlight the need for research into the design of the containers themselves, particularly in terms of aerodynamics and choice of materials. For example, Yu et al. (2025) have suggested that **plastic containers are more suitable for transporting broiler chickens than iron containers because they have lower thermal conductivity, mitigating the effects of extremes of temperature.**

4.2.2 Interaction of other risk factors with space allowances

4.2.2.1 Preparation for transport and loading/unloading

When poultry are transported by road, several operational stages other than the journey itself can affect the health and welfare of the animals. These include the preparation of the birds for transport, catching the birds, crating and uncrating them, and loading and unloading the containers onto and from the vehicle. The risk factors that affect the emotional and physical state of individual birds, along with the duration of the potential negative consequences for each, are summarised in *Table 7*.

Table 7. Risk factors for emotional and physical deterioration during transport phases other than the journey itself and their effects over time. X = the presence of a risk at a given stage, (+) = the potential presence of a risk at a given stage, + to +++ = presence and intensity of consequences over time. Data adapted from the EFSA report (EFSA, 2022).

Risk factor for welfare	*Preparation for transport*	*Loading/unloading of birds into/from containers (catching and crating/uncrating) **	*Loading/unloading containers into/from the lorry***
Feed withdrawal	X		
Water withdrawal	X		
Handling		X	X
Containment/restriction/ restraints		X	X
Consequences over time			
Prolonged hunger		+	++
Prolonged thirst		+	++
Stress/injuries	(+)	from + to ++	from + to +++
*Thermal stress****	(+)	from + to ++	from + to +++
Restriction of movement	(+)	+	+

** Animals can be loaded into containers manually or mechanically (e.g. using conveyor belts).*
*** Prolonged thirst and hunger during these stages occur because poultry may have already been fasted for several days prior to transport. In such cases they do not result from these stages alone. The intensity of hunger and thirst therefore increases over time and is greatest during unloading.*
**** Major risk of DOA (EFSA, 2022)*

The **loading method would appear to be one of the main causes of injury to poultry**, as does **the loading density of the container** as crating takes place. When birds are caught manually, authors **recommend catching and carrying the birds by the abdomen (or chest) in an upright position and holding them (using one or two hands) with their wings pressed against the handler's body** (Delezie et al., 2007; Kittelsen et al., 2018; Unterholzner et al., 2025). Also, the EFSA states that, **when equipment is properly adjusted, mechanical loading of birds into containers is less likely to cause injury than manual methods.**

4.2.2.2 Journey planning and transport duration

As the summaries in *Table 7* and *Figure 1* show, transport duration is an exacerbating factor for negative interactions between the various risk factors relating to poultry welfare. This is particularly true for the risks of exposure to thermal stress and prolonged thirst and hunger, the consequences of which worsen over time (and can lead to the death of the birds)[11]. The risk of injury would also appear to increase with transport duration. Indeed, a positive correlation has been demonstrated between the number of lesions on turkey carcasses and transport duration (although such a correlation has not been found for broiler chickens, EFSA, 2022).

To minimise the duration of each stage, and hence the total time spent by each individual animal in transport containers, EFSA recommends that there should be **coordination between all stakeholders** (farmers, transporters, abattoirs), limits should be placed on journey times, **and account should be taken of weather conditions when planning journeys to reduce the risk of heat stress** (see below).

4.2.2.3 Temperature

Heat stress is one of the most significant factors to affect poultry mortality during transport[12] (Averós et al., 2020; Çavuşoğlu & Petek, 2021; Justova et al., 2025). There are effectively two ways in which the space allowance (floor area and container height) can impact temperatures and moisture levels in containers and in the lorry:

1. by altering air circulation within and between containers[13];
2. by allowing birds to adopt positions to cool themselves (spreading and opening their wings, stretching their necks, moving apart from other birds), or by preventing them from doing so.

Additionally, these two effects interact, each exacerbating the other: **poor air circulation increases temperature and humidity, which is itself increased by the birds' perspiration.** In turn, **the increase in temperature and humidity reduces the effectiveness of poultry's thermoregulatory mechanisms**. Conversely, **high loading density within containers appears to improve the ability of poultry to cope with cold stress**, particularly through the proximity of individual birds or huddling behaviours (EFSA, 2022; Yu et al., 2025).

[11] For transport times (from preparation to uncrating) exceeding 12 hours, the EFSA recommends provision of water and feed to mitigate negative effects on the health and emotional state of the animals.
[12] With the exception of laying hens with poor feather cover, who are more susceptible to low temperatures.
[13] The majority of lorries are equipped with passive ventilation (vents on the sides and at the rear) only.

5 Conclusion and mitigating actions

5.1 Conclusion

In conclusion:

The transport of poultry (understood as the period beginning with food withdrawal and ending with the unloading of the birds from the containers) is inherently stressful for the animals (EFSA, 2022; Bergman et al., 2025; Marques et al, 2016). Any adjustments made to transport conditions, and more specifically, here, to the space allowance in the containers, can therefore seek only to **mitigate the negative impacts of transport. They are not therefore, properly speaking, measures that achieve welfare**.

During road transport, poultry are exposed to **numerous risk factors that can affect their state of health, both psychological** (stress) **and physical** (injuries, heat, death, etc)**. When the loading density within the containers is increased, these factors are exacerbated either directly** (e.g. restriction of movement) or **indirectly** (e.g. heat stress). Meanwhile, **other transport parameters, mainly temperature and humidity, modify the impacts of the space allowance** (floor area and container height) on the birds. Thus, at low temperatures, high stocking densities inside the containers would appear to enable the birds to cope better with cold stress. Conversely, at high temperatures, increasing the space allowance helps individual birds to thermoregulate, thereby limiting their release of additional moisture into the atmosphere (which itself increases heat stress) through panting. In addition, an increase in the space allowance (mainly in terms of container height) has been associated in some studies with an increased number of scratches (attributed to overlapping) and injuries (attributed to falls). Hence**, a balance must be found between the increased risk of physical trauma from the greater space available and the risks associated with a reduction in space** (inadequate ventilation, potentially fatal heat stress, restriction of the available behavioural repertoire).

In short, increasing the floor space allowance and headroom for each bird inside the containers helps to **improve the animals' comfort** and reduces their stress. Conversely, increasing the space allowance also tends to **increase the risk of injuries** related to falls or overlapping. Meanwhile, **the lack of data for the full range of species considered in this opinion makes it impossible to provide a scientific answer to the question** posed[14].

Last, **other parameters greatly influence the conditions under which birds are transported: the methods of catching and loading/unloading are thought to be the main risk factors for injury, and the total time spent in containers is thought to aggravate negative effects on welfare (Figure 1).**

[14] 'Is it the case that [poultry] transported by road at the densities and heights set out in the proposed regulatory revision to Regulation 1/2005 are more at risk of [overlapping] and/or injuring themselves than poultry transported by road at the densities and heights laid down in the current Regulation (Regulation 1/2005)?'

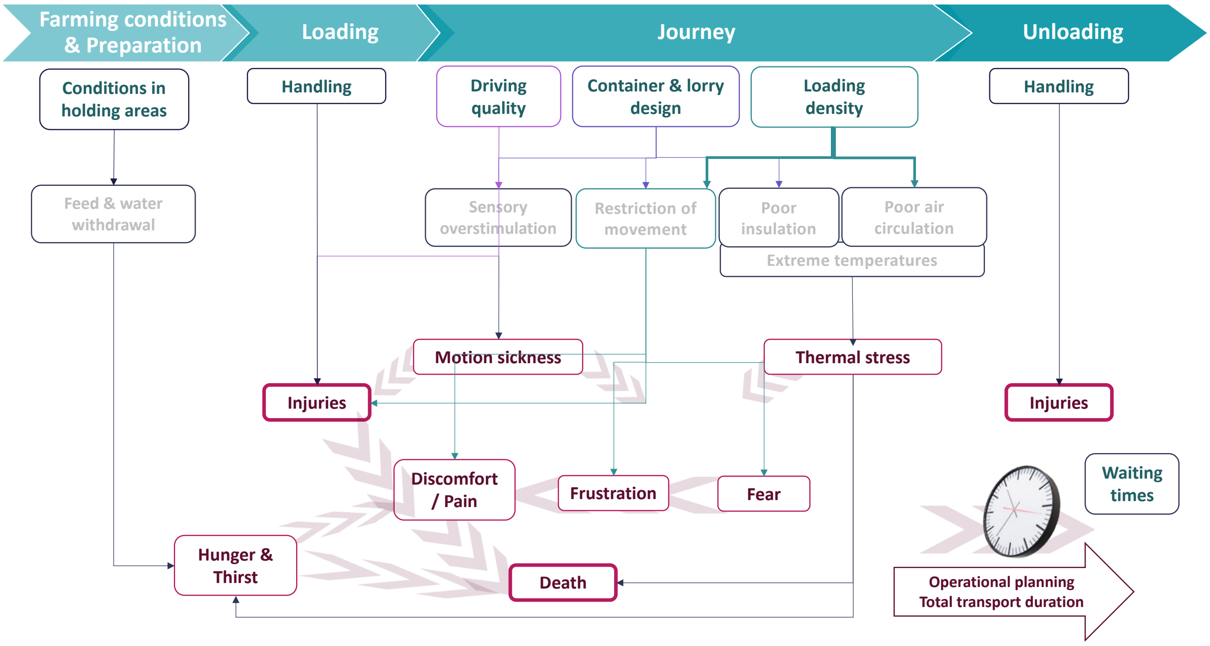

Figure 1. Summary of risk factors for poultry during transport and their interactions. *For each stage of transport (shown at the top), the associated risk factors are shown (in teal and grey), which are themselves linked to the consequences for the birds (in red). Each arrow represents a causal link, while >>> represents an increase in the effect over time.*

5.2 Actions to mitigate the risk of injury and overlapping independently of loading density within the containers

For researchers

To achieve a better understanding of the potential consequences for the risks of injury and overlapping of an increase in the space allowance (floor area and container height) per bird in transport containers, it is essential for further research to be conducted comparing current transport practices with the regulatory proposal. In particular, it would be of relevance to include more specifically behavioural studies (e.g. studies involving video recordings) in this research so that certain behaviours, such as overlapping during transport, can be directly quantified. Last, there is a paucity of studies covering certain species such as game birds, ducks, laying hens, turkeys, guinea fowl and quail. Research on the specific characteristics of these species (primarily those of non-domestic birds) should provide a better understanding of their needs during transport.

For training bodies

The loading of the birds into containers and their later removal (crating and uncrating) are among the transport stages presenting the greatest risk in terms of injury. When delivering training to handlers and transporters or machine and equipment operators for these purposes, it is therefore essential to reinforce good practice in relation to the capture and handling of poultry (a calm approach, safe movements, etc.), the recognition of behavioural indicators of stress, and good driving practices (gradual braking, maintaining safe distances, anticipating turns, etc.), along with their impacts on the protection of birds during transport.

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Appendix 1 . Definitions of physiological indicators mentioned in the assessment of stress and injury during poultry transport

Term	Definition	Use for stress or injury assessment	Sampling
ALAT (Alanine Aminotransferase)	An enzyme found mainly in the liver, the level of which in the blood is used to detect liver damage.	Elevated ALAT levels may indicate liver damage or metabolic stress affecting the liver.	Blood
Albumin	The main plasma protein, essential for maintaining oncotic pressure and transporting various molecules.	A decrease in albumin may be observed in cases of chronic inflammation or prolonged stress, affecting nutritional status and liver function.	Blood
AST (Aspartate Aminotransferase)	An enzyme found in various tissues (liver, muscles, heart), used to detect tissue damage.	An increase in AST may indicate muscle or liver damage, often associated with physiological stress or trauma.	Blood
CK (Creatine Kinase)	An enzyme found in muscles and other tissues, involved in energy production.	Elevated CK often indicates muscle damage or intense exercise, which can be induced by significant physical stress.	Blood
Cortisol	Cortisol is a steroid hormone produced by the adrenal cortex that regulates metabolism, inflammation and immune response. It is secreted in response to activation of the hypothalamic-pituitary-adrenal axis during stressful situations.	In stressful situations, increased cortisol levels enable the rapid mobilisation of energy needed to activate the 'fight or flight' response. However, prolonged exposure to high cortisol levels can disrupt physiological balance and negatively affect overall health.	Blood, saliva and hair
Glucose	A simple sugar molecule found in the blood that serves as a source of energy for cells.	During periods of stress, the release of hormones (adrenaline, cortisol) can lead to hyperglycaemia, indicating increased energy mobilisation.	Blood
Haematocrit	Ratio of blood cell volume to total blood volume. It is obtained by centrifugation, which separates blood cells from plasma.	An increase in haematocrit may reflect haemoconcentration, often due to dehydration or physiological stress.	Blood
Haematology	The study of the cellular components of blood (red blood cells, white blood cells, platelets) and their proportions.	Changes in haematological parameters (e.g. leukocytosis or changes in red blood cell count) may be responses to stress.	Blood
Haemoglobin	Red-coloured heteroprotein found in red blood cells	An increase in haemoglobin levels may be associated with stress or dehydration.	Blood
Lactate	A salt of lactic acid, often measured to assess the intensity of anaerobic glycolysis.	High lactate levels indicate anaerobic glycolysis, typical in cases of intense physical exertion or metabolic stress.	Blood and muscle
Lymphocyte	A mononuclear blood cell classified according to its diameter as large (9 to 15 µm) or small (6 to 9 µm) lymphocyte, which plays a fundamental role in the body's immune response and is generally found in the circulatory system and in the 'lymphoid organs' (lymph nodes, spleen, thymus).	A decrease in the percentage of lymphocytes is often interpreted as a sign of chronic or acute stress.	Blood
MCH (mean corpuscular haemoglobin)	Average haemoglobin level per red blood cell (expressed in pg), obtained by calculating the ratio of total haemoglobin (g/L) to the number of red blood cells in one litre (n/L).	A value below the reference value is interpreted as a sign of anaemia. Anaemia can be a marker of stress.	Blood
MCHC (Mean Corpuscular Haemoglobin Concentration)	Average haemoglobin level in the volume occupied by red blood cells in the blood (expressed in g/L), obtained by dividing the haemoglobin level by the haematocrit.	A value below the reference range is interpreted as a sign of anaemia. Anaemia can be a marker of stress.	Blood
MCV (Mean Corpuscular Volume)	Average volume of all red blood cells measured (expressed in fL)	A value below the reference range is interpreted as a sign of anaemia. Anaemia can be a marker of stress.	Blood
NEFA (Non-esterified fatty acids)	Free fatty acids circulating in the blood, indicators of the mobilisation of lipid reserves.	An increase in NEFA suggests increased mobilisation of fat in response to an energy deficit, often observed in situations of prolonged stress.	Blood (plasma)
PCV (Packed Cell Volume)	Packed Cell Volume or haematocrit: percentage of blood volume occupied by red blood cells.	Variations in PCV may reflect changes in fluid status (dehydration or overhydration) or responses to stress (changes in blood volume).	Blood (haematocrit)

Term	Definition	Use for stress or injury assessment	Sampling
Proteins	All plasma proteins such as albumin and globulin	Variations (increase or decrease) may reflect nutritional imbalances, dehydration or a stress-related inflammatory response.	Blood
Sources	https://www.cscq.ch/SiteCSCQ/FichierPDF_FR/FT-MCV-MCH-MCHC-fr.pdf		

French Reference Centre
for Animal Welfare

www.cnr-bea.fr/en/ | contact@cnr-bea.fr