

REVIEW

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Catching and loading of laying hens and broiler chickens: status quo, challenges and recommendations

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Abstract

Catching and loading represent critical phases in the poultry production chain and are repeatedly identified as major risk factors for compromised animal welfare. This scoping review synthesises the current scientific evidence on catching and loading practices in laying hens and broiler chickens, with particular emphasis on animal-based welfare indicators, handling techniques, and operational constraints under commercial conditions. Peer-reviewed studies addressing manual and mechanical catching, inverted versus upright handling, and one-leg versus two-leg grasping were systematically assessed. Across both laying hens and broiler chickens, inverted manual catching is consistently associated with increased fear-related behaviour, elevated physiological stress responses, and a higher prevalence of wing injuries, whereas upright handling generally reduces wing flapping and handling-related trauma. However, upright catching is substantially more labour-intensive and time-consuming, highlighting a trade-off between animal welfare benefits and ergonomic and economic feasibility. Catching in an upright position is possible in a similar amount of time to inverted catching, but only with a larger number of personnel. Evidence for mechanical catching systems is heterogeneous: while such systems may reduce fear-related struggling compared with inverted manual catching, welfare outcomes strongly depend on machine design, operational settings, and bird-machine interactions. The review further examines avian respiratory physiology in the context of inverted handling and critically appraises the frequently cited assumption that inversion compromises respiration through visceral compression. Current evidence does not support this mechanism, as direct physiological measurements under inverted handling are lacking. Overall, the available literature is characterised by marked methodological heterogeneity, limiting direct comparability between studies. Nevertheless, consistent patterns indicate that minimising inversion, agitation, and handling-related impacts is central to improving welfare during depopulation. These findings underscore the need for outcome-oriented handling practices, improved crew training, and future research incorporating direct physiological measurements to better inform welfare-oriented and legally compliant catching strategies.

Keywords Depopulation, Inverted catching, Upright catching, Catching machine, Stress assessment, Poultry welfare

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Introduction

Importance of catching and loading for poultry welfare

Animal welfare has become a key benchmark in live-stock production, spanning all stages from breeding to slaughter. Within this continuum, the catching and loading of birds are increasingly recognised as critical phases that pose substantial challenges to meeting the requirements of low-stress and low-injury depopulation [1–5]. In Germany alone, several hundred million poultry are transported to slaughterhouses each year. In 2024, 626.7 million broiler chickens were slaughtered, while the average number of laying hens kept was approximately 51.4 million [6, 7]. Despite their routine nature, these procedures continue to be associated with a high risk of stress, respiratory strain, and physical injury in birds, and they often fall short of animal welfare standards.

Beyond animal welfare, catching and loading also place significant physical and psychological strain on human personnel. Economic constraints and the pressure for time efficiency further influence the choice and execution of catching methods, creating potential conflicts between animal welfare, worker safety, and operational feasibility.

Legal and regulatory framework

At international level, the *European Convention for the Protection of Animals during International Transport (revised)* (CETS No. 193) identifies loading and unloading as critical phases and requires that animals be handled in a manner that avoids injury and unnecessary suffering [8]. Within the framework of the *European Convention for the Protection of Animals kept for Farming Purposes* (ETS No. 87), the Standing Committee adopted the recommendation concerning domestic fowl (*Gallus gallus domesticus*), which specifies species-specific requirements for laying hens and broiler chickens, including provisions on stockmanship, catching and handling [9]. This recommendation requires that birds should not be deprived of food or water before transport except in the case of transport to a slaughterhouse which is close to the point of production and that the time birds are held in containers before transport should be limited. Catching and loading fall under the scope of Council Regulation (EC) No 1/2005 which applies from the point at which animals are first handled with a view to loading and requires that handling is carried out by trained personnel in a manner that avoids injury and unnecessary suffering [10]. It is furthermore prohibited to apply pressure to particularly sensitive parts of the body in a manner that causes unnecessary pain or suffering to the animals (Annex I, Chapter III, No. 1.8(b) of Council Regulation (EC) No 1/2005) [10], as well as to lift or drag animals by their legs or otherwise handle them in a way that causes unnecessary pain or suffering (Annex I, Chapter III, No. 1.8(d)). Together, these instruments constitute the core

European framework governing the preparation of poultry for transport to slaughter. A recent judgment of the District Court of Rotterdam (judgment of the District Court of Rotterdam of 24 November 2023, case nos. ROT 22/2933, 22/2935, 22/2936) has interpreted the applicable legal framework in a way that considers current catching and loading practices to be incompatible with EU law, in particular with the requirements of Council Regulation (EC) No 1/2005.

Current catching and loading practices in commercial poultry production

Before depopulation begins, the responsible animal keeper or a designated manager assesses the birds' general fitness for transport. Preparations for catching and loading typically take place 6–8 hours before loading. In addition, a compulsory ante-mortem inspection by the competent veterinary authority must be carried out within 24 hours prior to slaughter in accordance with Article 11 (2) and (5) of Implementing Regulation (EU) 2019/627. This inspection primarily serves food hygiene purposes and the assessment of slaughter fitness and includes a general appraisal of animal health and welfare conditions at flock level, rather than a detailed evaluation of the transport fitness of individual birds. In practice, depopulation is frequently scheduled for the late evening or night in order to take advantage of reduced light intensity, the birds' natural resting behaviour and cooler ambient temperatures. During this preparation phase, birds are usually fasted for several hours, and the barn is reorganised to facilitate animal movement and access to transport containers.

Laying hens

Laying hens are typically depopulated at the end of a laying cycle at approximately 80–100 weeks of age [11, 12]. Due to their high demand for calcium for eggshell formation, end-of-lay hens show an increased susceptibility to skeletal fragility and fractures [13, 14]. Housing systems, particularly multi-tier aviary systems, strongly influence the choice and feasibility of catching methods. Although the majority of laying hens in Europe are still kept in enriched cages [15], conventional cage systems have been banned in Germany, resulting in a husbandry structure dominated by non-cage systems, particularly aviary housing [16]. Ongoing shifts towards more animal-friendly systems aligned with the ethological and physiological needs of the animals further reinforce this development.

In aviary barns, hens are typically caught either on the tiers or in the litter area by grasping one or both legs. Toes often have to be released from perches or grids before birds can be lifted or pulled sideways. In common practice, catchers remove hens from the aviary either

individually, holding several birds in the free hand by one leg, or by grasping two or three hens at a time, each by one leg [17]. The hens are then typically handed down along a human chain and carried in an inverted position, with one to three birds held per hand, before being loaded into crates. This practice is subject to ongoing legal debate, as the Rotterdam District Court concluded that carrying laying hens in an inverted position is incompatible with the requirements of Council Regulation (EC) No 1/2005. Depending on barn layout and the positioning of transport containers, birds may need to be carried over several metres before crating, which increases both the risk of injury to the birds and the physical workload for staff. The widespread use of inverted carrying is largely attributable to operational efficiency, as several birds can be transported simultaneously along a human chain. Ideally, crates are placed on trolleys in advance and rolled into the aviary, allowing hens to be loaded directly from the housing system. However, this requires prior removal of litter from the floor and sufficient space to manoeuvre complete container modules inside the barn. Crates for end-of-lay hens can be loaded either from the top or from the side and typically hold approximately 8–16 hens per unit. On average, around 4,800–9,000 hens are transported per truck, depending on truck type, container type live weight and, therefore, legally permitted stocking densities per unit (personal communication, German slaughterhouse employee, 2025 and catching crew, 2026). Depopulation of laying hens in multi-tier aviary systems presents unique practical challenges due to the vertical structure of the housing system, restricted accessibility of birds, and the need for workers to move between elevated tiers. Figure 1 shows the depopulation of laying hens in an aviary system.

Broiler chickens

Commercial broiler chickens (male and female birds) are generally reared in floor systems and reach a live weight of around 2.3–3.0 kg at slaughter [16, 18] after 40–42 days of fattening. However, thinning at live weights of approximately 2.0 kg is also common in commercial broiler chicken production [19]. In general, the rapid growth of broiler chickens is associated with locomotor impairments and increased cardiovascular strain, which may be exacerbated by the stress of depopulation [20]. Under common commercial conditions reported by farmers and the authors' field observations, birds are caught either manually or by automated systems, typically in darkened barns to reduce activity and facilitate handling. Under the most common manual procedure, catchers usually grasp two or more broiler chickens simultaneously by one leg each, lift them, and place them upside down into transport crates or drawers of modular container systems. Depending on the body weight of the birds, a single catcher may carry

three and, in some cases, up to five broiler chickens at a time, typically distributed between both hands. The compliance of this practice with current animal welfare legislation remains debated, particularly where birds are carried by a single leg or in an inverted position. As broiler chickens are caught at floor level, depopulation involves a large number of repetitive bending and lifting movements. Consequently, changes in catching technique may also affect the physical workload of catching crews. The transport modules commonly used for broiler chickens consist of container systems with multiple drawers stacked vertically, which are loaded from the bottom upwards. To reduce the physical workload of catching crews, transport containers are positioned within arm's reach and continuously moved forward, so that birds do not need to be carried over long distances. Typically, each container module is loaded by two catchers working in parallel. Depending on the container system (size of the drawers), the live weight, and climatic conditions, approximately 40–55 animals are loaded per drawer. A fully loaded transport module may contain several hundred birds, and a standard truck can carry approximately 8,000–16,000 broiler chickens per journey, depending on compartment design and target stocking densities. Loading a standard truck under commercial conditions generally takes between 45–60 minutes and involves 6–8 catchers, with duration influenced by flock size, stocking density, barn layout, and the number and efficiency of the catchers (personal communications with employees in the broiler chicken farming sector, 2024, 2025, 2026).

Automated catching systems are used in some broiler chicken operations as an alternative to manual handling. In Germany, only about 5% of broiler chickens are loaded mechanically [21]. These systems typically rely on conveyor belts or rotating drums to collect birds from the floor and transfer them into transport containers. Broiler chickens are loaded into container modules in an upright position via a conveyor belt system, with stocking density within the container drawers being regulated according to a preset target weight. Operation of such systems usually requires a catching crew of four to seven people to manage the machine and load the containers. Depending on operational conditions, automated systems can achieve throughput comparable to manual catching. Although they may reduce physical workload and standardise handling, their welfare implications remain unclear. Figure 2 illustrates the catching process in broiler chickens either by hand or by a catching machine.

Respiratory system of chickens

During catching and loading, birds are often handled in an inverted (upside-down) position. This unnatural body orientation has been discussed as a potential welfare risk, as inversion may cause compression of the heart and

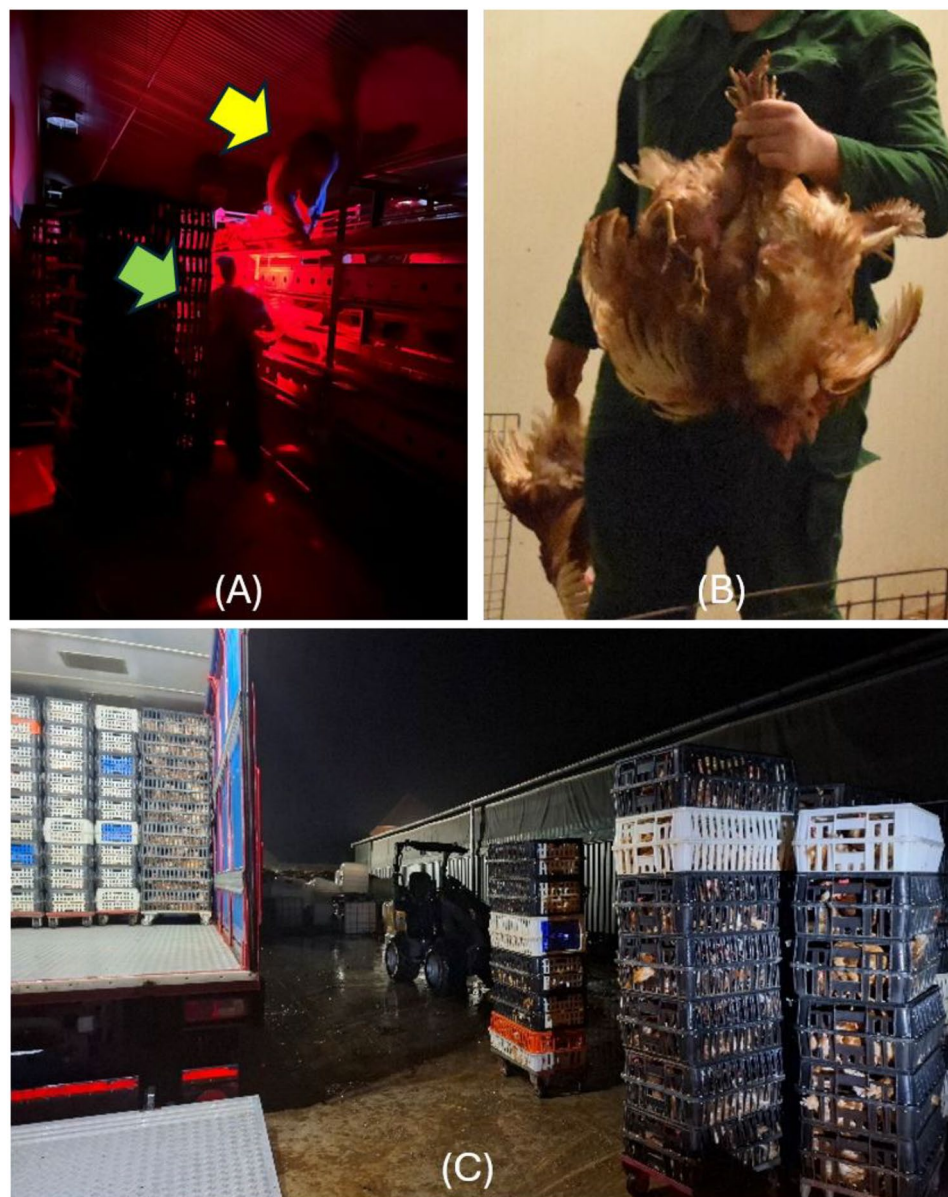


Fig. 1 Depopulation of a Lohmann Brown laying hen flock at end of lay kept in an aviary system: **(A)** a catcher on an upper tier (yellow arrow) catches the hens and hands them down to the person standing below (green arrow); **(B)** hens are carried in an inverted position; and **(C)** typical crates and truck loading configuration

lungs by the abdominal viscera and thereby compromise breathing and cardiac activity [1]. These risks cannot be fully understood without considering the specific characteristics of avian respiratory physiology.

Avian respiration relies on relatively rigid lungs and a system of air sacs that function as ventilatory bellows (Fig. 3). Ventilation is achieved by thin-walled air sacs that expand passively and drive airflow through the lungs. Because birds lack a diaphragm, ventilation depends on coordinated movements of the sternum, rib cage and associated musculature [22]. Breathing must therefore not be restricted by external pressure on the rib cage or abdomen

[23], and changes in body posture may influence air sac volume and ventilatory efficiency, particularly when movement of the sternum or displacement of the viscera is restricted [24]. Excessive restraint of chickens can impair air sac expansion and compromise ventilation, potentially leading to respiratory compromise [25].

During catching and loading, a key and controversial question is the extent to which body position during handling or restraint affects respiratory function and impairs ventilation. Soum [26], as cited in King and Payne [27], observed a reduction in ventilation of 20–25% in pigeons and ducks when the birds were placed on their backs.

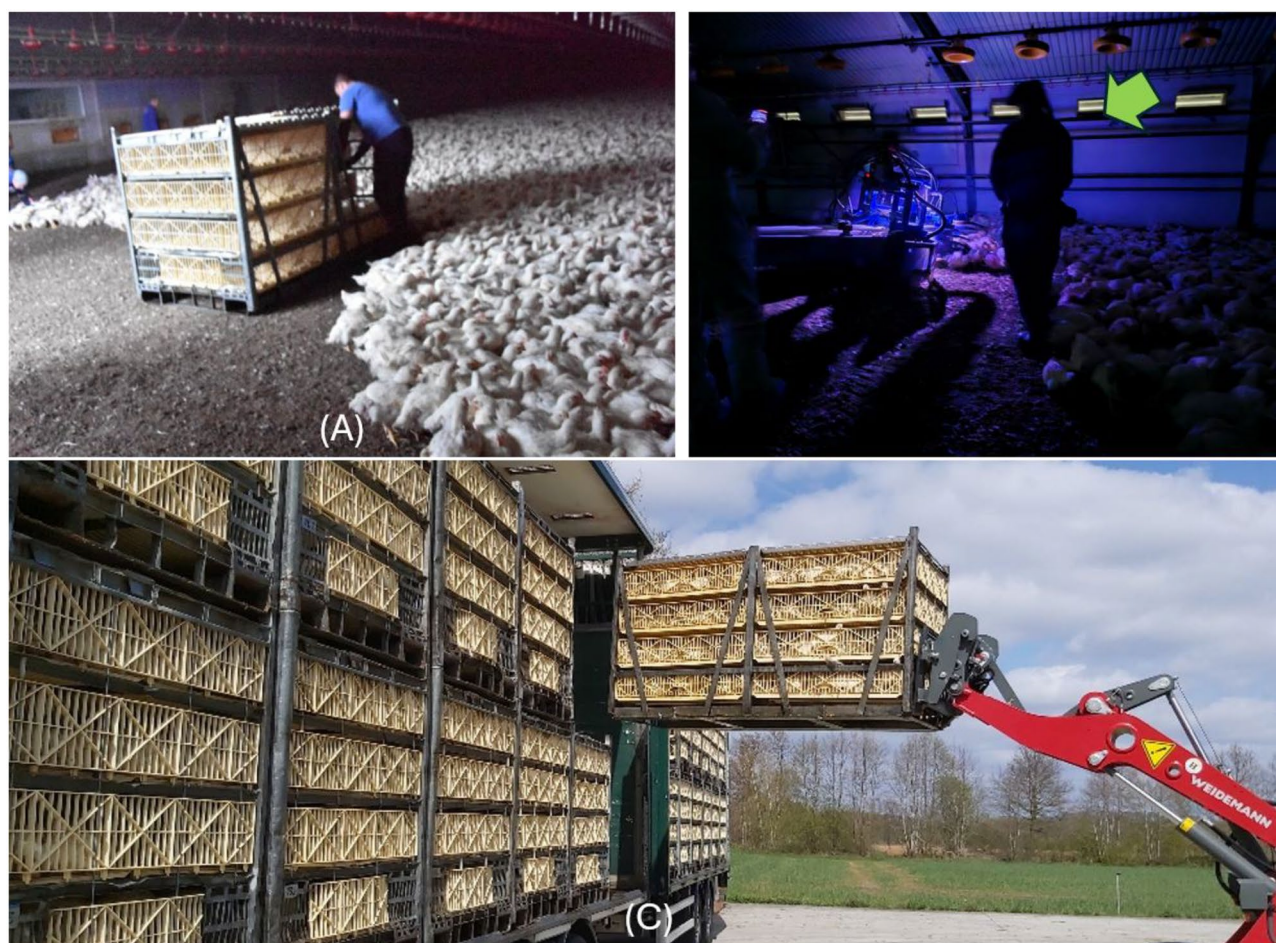


Fig. 2 Depopulation of a Ross 308 broiler flock: (A) manually caught, (B) caught by a catching machine with one person at the front (green arrow) who operates the machine and (C) crate modules loaded on the truck

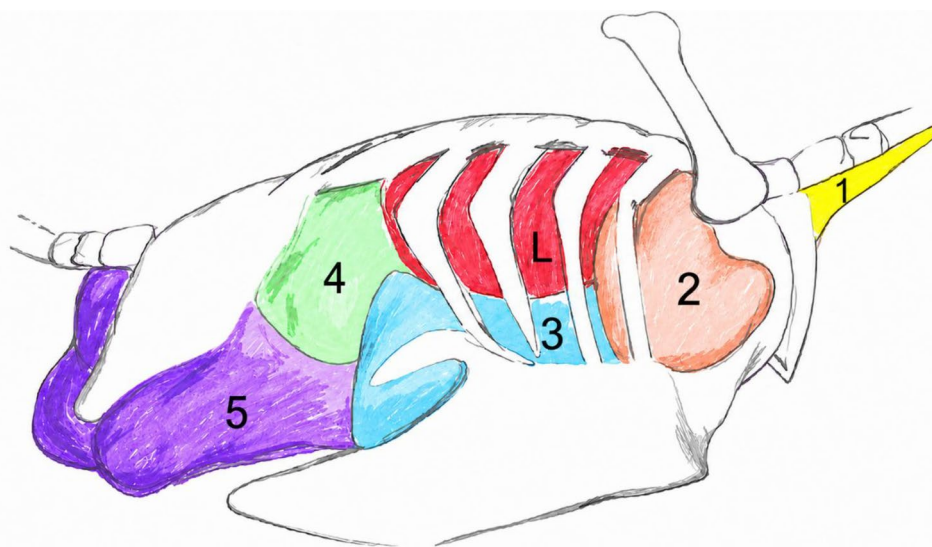


Fig. 3 Simplified schematic representation of the air sac system in the chicken (lateral view; paired sacs shown unilaterally): 1 = cervical air sac, 2 = clavicular air sac, 3 = cranial thoracic air sac, 4 = caudal thoracic air sac, 5 = abdominal air sac and L = lung

Similarly, King and Payne [27] reported significant effects of body posture on respiration in chickens. The amplitude of breathing was reduced by 40–50% when chickens were placed on their backs for short experimental periods (10 s to 60 s), accompanied by an increased frequency of breathing of 20–50%. In addition, King and Payne [27] reported a reduction in minute ventilation of 10–60% associated with changes in body posture. Jones et al. [28] observed an increased respiratory rate of approximately 59 breaths per minute in shackled broiler chickens. However, this study did not include a control group of non-shackled chickens, limiting direct comparison. Wong et al. [29] found no significant differences in respiratory rate or tidal impedance variation of the cranial air sacs in isoflurane-anaesthetised chickens positioned in dorsal, ventral, right lateral, or left lateral recumbency. However, significant alterations in respiratory pattern, including changes in rhythm, distribution and coordination of ventilation between different lung regions and air sacs were observed. The authors concluded that these changes were likely attributable to body positioning, as respiratory muscle function may be compromised when chickens are placed in postures other than the upright position. Despite the frequent use of respiratory impairment as an argument against inverted catching, no studies have been identified that specifically investigate the physiological effects of an inverted (upside-down) body position on respiratory function in chickens.

Objectives of the review

Despite the widespread use of different catching and loading methods, important uncertainties remain regarding their welfare implications and the scientific evidence supporting current recommendations and legal interpretations. This is particularly relevant in light of ongoing debates about inverted versus upright handling and recent legal challenges to established commercial practices. This scoping review aims to synthesise and critically appraise the scientific evidence on catching and loading procedures in laying hens and broiler chickens, with particular emphasis on animal welfare outcomes and their relevance for the interpretation of current legal and regulatory requirements.

Specifically, the review addresses the following questions:

- (1) What evidence exists regarding the effects of different catching methods on behavioural, physiological, and injury-related welfare indicators in laying hens and broiler chickens?
- (2) To what extent do findings differ between laying hens and broiler chickens, and how transferable are results across these production types?

- (3) What scientific evidence supports or contradicts the frequently cited assumption that inverted handling compromises respiratory or circulatory function in poultry?
- (4) Does the current evidence base provide sufficient scientific support for regulatory recommendations and legal interpretations concerning catching and loading practices?

In addition, in line with the One Health concept, the review considers documented effects of depopulation practices on human health and discusses implications for sustainable and welfare-oriented poultry production.

Materials and methods

The literature review was conducted to evaluate the welfare implications of different depopulation and catching methods in poultry, with a particular focus on laying hens and broiler chickens. Relevant peer-reviewed studies investigating manual and mechanical catching, one-leg and two-leg catching, as well as upright and inverted handling methods, were identified through a structured literature search.

A literature search was conducted between May and November 2025 using Google Scholar, PubMed, and Web of Science. Both English- and German-language publications were considered. Search terms included combinations of species- and procedure-related terms such as “laying hens”, “spent hens”, “broilers”, “poultry”, “depopulation”, “catching”, “catching methods”, and “crating”, combined with outcome-related terms such as “health”, “welfare”, “respiratory system”, “injuries”, “stress”, and “stress indicators”. Corresponding German search terms were also used. Additional relevant publications were identified through manual screening of the reference lists of included studies.

The review followed a structured scoping review approach. After removal of duplicates, titles and abstracts were screened for relevance with regard to poultry catching, loading, crating, or depopulation procedures. Potentially relevant publications were subsequently assessed in full text against the predefined inclusion and exclusion criteria. Studies meeting the eligibility criteria were included in the descriptive synthesis.

Studies were included when they assessed animal-based welfare indicators during catching, loading, crating, or depopulation procedures. Relevant outcome measures comprised physiological stress indicators (e.g. corticosterone concentrations, heterophil-to-lymphocyte ratio, body temperature, and creatine kinase activity), behavioural responses (e.g. tonic immobility (TI) and wing flapping), injury prevalence (e.g. haematomas, fractures, and dislocations), mortality, and operational parameters such as loading duration and labour

requirements. Studies focusing on poultry species other than laying hens or broiler chickens, transport procedures without direct relation to catching or loading, or slaughter and meat quality outcomes without assessment of welfare- or stress-related parameters were excluded.

Data from eligible studies were extracted and grouped according to poultry type (laying hens or broiler chickens) and catching method. Reported outcomes were synthesised descriptively because substantial heterogeneity existed among studies regarding animal age and weight, housing systems, environmental conditions, handling procedures, outcome measurements, and reporting methods. Consequently, a quantitative meta-analysis was not considered appropriate. In line with the exploratory nature of a scoping review, no formal quality assessment or risk-of-bias evaluation of individual studies was performed.

A total of 30 studies met the inclusion criteria and were included in the review. Of these, 22 studies focused on broiler chickens and 8 on laying hens. The extracted findings were summarised in comparative tables to facilitate the evaluation of welfare-related effects associated with different depopulation and catching methods. Additional source types, including legal regulations, government documents, reports, and book chapters, were consulted to provide contextual background and support the introductory sections of the manuscript but were not included in the analysis of assessment methods and study outcomes.

Results and discussion

Welfare aspects of catching and loading of laying hens – scientific studies

Scientific investigations into catching and loading in laying hens date back to the early 1990s and primarily examined stress responses and injury risks associated with different handling methods [30–32]. In his review, Broom [30] summarised experimental findings indicating a lower prevalence of fractures and reduced plasma corticosterone concentrations in hens that were carefully removed from cages and placed upright into transport crates, compared with birds carried inverted by a single leg.

Studies conducted under both experimental and commercial conditions provide a heterogeneous yet complementary body of evidence. Some studies compare upright and inverted handling methods, others contrast baseline conditions with depopulation procedures, while further investigations focus on one-leg versus two-leg catching or evaluate specific handling interventions.

Table 1 synthesises these findings by juxtaposing catching methods and reported outcomes across studies, thereby providing a structured basis for the subsequent discussion. The table shows that only a few studies have

examined specific catching methods in laying hens and that these studies covered different welfare indicators, which restricts direct comparison of their findings.

General effects of catching or crating of laying hens

The predominance of manual catching and the structural complexity of modern aviary barns make the depopulation of laying hens a particularly labour-intensive and time-consuming process. During depopulation, both animal welfare risks—such as fractures, bruising, heat stress and handling-related stress—and occupational health risks for workers must be considered. Post-mortem data indicate traumatic limb and trunk injuries in approximately 2.78% and 0.01% of end-of-lay hens at slaughter, respectively [36]. In parallel, epidemiological studies among poultry slaughterhouse and farm workers consistently report high prevalences of work-related musculoskeletal disorders.

Against this background, experimental studies have investigated the acute physiological stress responses associated with depopulation-related procedures. Moneva et al. [33] investigated the combined stress effects of catching, social regrouping, loading, and exposure to a novel environment in 55-week-old free-range Lohmann laying hens ($n=25$). In the study, hens were caught and placed together in a common transport crate, during which they had no access to feed or drinking water. Blood samples were collected from each hen only once, to avoid stress amplification associated with repeated sampling, at 5, 15, 30, 60 or 90 min after loading. Plasma corticosterone concentrations increased significantly within the first 30 min after loading ($p<0.01$) and declined thereafter, whereas the heterophil-to-lymphocyte ratio showed a significant increase from 60 min onwards. However, plasma corticosterone concentrations at 90 min remained higher than those measured at 15 min, indicating that the hens were still experiencing stress, albeit at a reduced intensity. The observed responses reflect the combined effects of the different stressors applied in the study, which could not be disentangled within the experimental design. The authors therefore concluded that neither corticosterone concentrations nor the heterophil-to-lymphocyte ratio alone provide a fully reliable assessment of welfare status, whereas their combined evaluation yields a more robust indication of stress. Building on such findings, subsequent research has explored whether targeted interventions during depopulation could mitigate stress and injury. Gerpe and Toscano [37] evaluated two potential welfare-improving measures during commercial depopulation: (1) trolley-based loading to reduce carrying distances and (2) the use of blue light to facilitate handling. Across two independent experiments involving approximately 300 hens per treatment group, neither intervention resulted in significant improvements

Table 1 Welfare indicators in laying hens under depopulation with different catching methods

Parameter	General effects of depopulation 	One (ONE)-leg vs. two-leg catching  vs. 	Upright (UP) vs. inverted (IV) catching  vs. 
Corticosterone	↑ 30 min after catching and crating (decreasing after 60 minutes but still higher than baseline [33]), ↑ after depopulation (4.33 vs. 3.97 ng/mL) compared with baseline [34]	-	↓ in UP hens [30]
H/L ratio	↑ from 60 min after loading [33]	-	-
Respiration rate	↑ after depopulation (41.1 vs. 36.3 breaths/min) compared with baseline [34]	-	-
Cloacal temperature	↑ in depopulated hens (36.28 °C vs. 35.81 °C at baseline) [34]	-	-
Comb temperature	↓ in depopulated hens (29.06 °C vs. 32.47 °C) compared with baseline [34]	-	-
Tonic immobility (TI)	↑ TI induction: baseline < depopulation (more attempts/failures) [34] = between baseline and depopulation in LAT1/LATSU [34]	-	↓ TI after UP [32]
Muscle strain (CK)	↑ after catching vs. baseline [34]	-	-
Wing flapping	-	-	↓ in UP (1.94 ± 0.50 vs. 4.02 ± 0.50; scale 1–7, lower scores indicate less wing flapping [35]) ↓ in UP (1.13 ± 0.63 vs. 1.73 ± 0.70 [35]), = [35] ↓ in UP [30]
Wing haematomas/injuries	Traumatic limb and trunk injuries in approximately 2.78% and 0.01% of end-of-lay hens at slaughter [36]	↑ in ONE (11–14% vs. 5% [31]),	↓ in UP, lower agitation [32]
Fractures	8.1% of hens sustained fresh fractures or dislocated joints [34]	-	↓ in UP, gentler handling (1.9 ± 0.5 vs. 4.4 ± 0.5) as well as better catcher-bird interaction (3.06 ± 0.60 vs. 4.41 ± 0.50 [35]), both on a 7-point scale with 1 = best and 7 = worst outcome
Fear-related behaviour	-	-	↓ in UP tendency towards less noise (4.79 vs. 4.57 on a 7-point scale [35]),
Handling quality	-	-	↑ in UP, requires more time per 1,000 hens [35]
Noise	-	-	-
Time/labour demand	-	-	-
Interventions (trolley/blue light)	= No significant change in physiological or injury outcomes [37]	-	-

↑ stands for increasing, ↓ stands for decreasing, = indicates no difference, and - not assessed. LAT1 = latency to first head movement following tonic immobility induction, LATSU = latency to stand up following tonic immobility induction

in physiological (peripheral cooling, respiration rate) or behavioural welfare (TI) indicators, nor did they reduce fracture incidence. To establish a broader baseline for welfare outcomes under routine commercial conditions, Gerpe et al. [34] examined catching, carrying, and crating practices during the depopulation of end-of-lay hens to establish baseline data on hen injuries, stress-related measures, fearfulness, and the experiences of human workers. The study was conducted on 15 commercial farms, primarily using multi-tier aviary systems (with one single-tier system), with flock sizes ranging from 2,040 to 13,540 hens. In total, 603 individual end-of-lay hens (72–85 weeks of age; various hybrids) were assessed. Depopulation on all farms was carried out by the producers themselves rather than by professional catching crews. Hens were caught individually using both hands and carried upright, holding them by their body with the wings pressed against the body to prevent wing flapping. For baseline measurements, data collection began within 30 s of catching the hens ($n = 255$ hens). In contrast to baseline collections, data collection during depopulation started after hens were in the crates for 12 to 30 min, a time frame based on observations that these measures reached their peak. The results indicated that approximately 8.1% of hens sustained severe injuries, including fractures and muscle damage after depopulation. During depopulation, plasma corticosterone concentrations were 16% higher than at baseline ($\chi^2 = 4.18$, $df = 1$, $p = 0.041$). Creatine kinase activation increased by 5.8% ($\chi^2 = 5.53$, $df = 1$, $p = 0.019$), cloacal temperature was elevated by 0.9 °C, and respiration rate increased by five chest movements per minute ($\chi^2 = 45.92$, $df = 1$, $p < 0.001$). In contrast, comb temperature was significantly lower during depopulation (-1.9 °C; $\chi^2 = 540.64$, $df = 4$, $p < 0.001$). Haematocrit values did not indicate a physiological response. Results of the TI test indicated increased fearfulness in depopulated hens, reflected by differences in the induction response ($z = 2.5$, $p < 0.05$). In contrast, neither latency to the first head movement ($\chi^2 = 207.93$, $df = 1$, $p = 0.81$) nor latency to stand up ($\chi^2 = 224.73$, $df = 1$, $p = 0.27$) differed between baseline and depopulation conditions. Taken together, these findings indicate that depopulation elicits pronounced physiological and behavioural stress responses, while also highlighting the need for further research that disentangles individual components of the catching, carrying, and crating process. In particular, factors such as lighting conditions, aviary design and time of day warrant closer examination as potential modifiers of injury risk and handling quality.

One-leg vs. two-leg catching of laying hens

Within manual inverted catching, further differentiation can be made between one-leg and two-leg grasping

techniques. Gregory et al. [31] investigated the effects of different catching methods on fracture incidence in end-of-lay brown hens housed in battery cages. The study was conducted on two commercial and three experimental farms. Six catching methods were examined: (1) single bird caught by both legs without hand support, (2) single bird caught by both legs with hand support, (3) single bird caught by both legs using a sliding technique, whereby the bird was pulled through the cage opening with a wooden breast support slide fitted over the feed trough, (4) single bird caught by one leg, (5) multiple birds caught by one leg, and (6) multiple birds caught by one leg using a sliding technique. Following catching, birds were euthanised using an overdose of pentobarbitone to ensure a convulsion-free death, and carcasses were subsequently examined for the presence of fresh skeletal fractures. Clear method-related differences in fracture incidence were observed: catching and removing hens by both legs resulted in significantly fewer fractures (approximately 5%) than catching by one leg, which caused fresh fractures in 11–14% of hens. In addition, the authors reported that removing hens individually rather than in bunches further reduced the occurrence of skeletal injuries. The transferability of these findings to contemporary floor and aviary systems is uncertain, as housing design strongly influences both the catching procedure and the risk of handling-related injuries.

Upright vs. inverted catching of laying hens

Beyond differences in grasping technique, the orientation in which hens are carried—upright versus inverted—has been identified as a key determinant of behavioural and physiological responses during handling. Jones [32] demonstrated that handling technique influences fear responses in laying hens. In an experimental setting, hens carried in an upright position prior to testing exhibited significantly shorter TI durations than hens carried upside-down, indicating lower fearfulness associated with upright handling.

A larger-scale field study by Delanglez et al. [35] directly compared upright and inverted catching on seven commercial farms (one single-tier barn and six aviary systems), involving approximately 3,000 hens per method and flock. Using animal-based indicators scored on seven-point scales, upright catching resulted in significantly lower wing-flapping frequency ($p < 0.001$), improved catcher–bird interaction ($p < 0.001$), gentler handling scores (mean $\pm$ SD: 1.9 ± 0.5 vs. 4.4 ± 0.5 ; $p < 0.001$), and fewer wing haematomas ($p = 0.04$). A trend towards reduced noise during the catching process was also observed for upright handling ($p = 0.08$). No significant differences between catching methods were found for other specific injuries, including wing fractures,

Table 2 Welfare indicators in broiler chickens under depopulation with different catching methods

Parameter	General effects of depopulation 	One (ONE)-leg vs. two-leg (TWO) catching  vs. 	Upright (UP) vs. inverted (IV) catching  vs. 	Manual (MAN) vs. machine (MECH) catching  vs. 
Corticosterone	-	-	-	= [38–40] ↑ in MAN when outdoor temperature > 20 °C ($\beta = 22.4$ [39]), = at end of MAN and MECH [41] = [39] - ↑ TI after MAN [44] (OR = 4.0 [40]) -
H/L ratio	= low H/L ratios, mostly age/season driven [42]	-	-	-
Cloacal temperature	↑ during crating; higher in summer; stronger responses in older/heavier birds [42]	-	-	-
Tonic immobility (TI)	TI/fear is handling-sensitive overall [40, 43, 44]	-	-	-
Creatine kinase (CK)	↑ with crating/transport; higher in older/heavier birds [42]	-	-	-
Wing flapping	↑ under inversion; reduced by gentler handling [43]	↑ in ONE [45] = [46]	↓ in UP [47–49]	↑ in MAN (OR = 2.11 [39]), ↑ flapping with higher rotor/belt speed [50, 51]
Wing haematomas/injuries	↑ injuries accumulate along chain; catching is a key origin but late scoring dilutes attribution [52, 53]	= [46] ↑ epiphyseolysis in ONE (1.1% vs. 0.43%) with longer catching time ↑ risk [45]	-	↓ wing bruises in early large-unit mechanisation [54] ↓ injuries in total in MECH (3.67% vs. 4.89% [55]), ↓ wing bruises in MECH (1.32% vs. 1.17%) ↓ leg bruises in MECH (0.56% vs. 0.47%) [40] ↑ in MECH vs. UP (15.5% vs. 17.7% [47]), ↓ wing haematomas in MAN (OR = 0.16 [56]), ↓ haemorrhages in MAN [53] = [57] = MAN vs MECH [39, 53, 56] ↑ fracture risk with machine flips (OR = 2.75 [39]) = MAN vs MECH (0.54 ± 0.60% compared to 0.39 ± 0.42% after manual catching ($p = 0.07$ [55]) ↑ fear proxies (flapping, TI) in MAN, but ↑ fear/impacts in MECH if settings poor or speeds too high [39, 44, 50]
Fractures	↑ wing fractures mainly arise during catching (0.1% → 1.9% post-catching [52])	-	= [48] = (0.73% vs. 0.70% [47])	-
Dead on arrival	-	-	-	-
Fear/handling quality	Gentle catching reduces agitation/injuries [43] Crew choice/training key [52]	↓ flapping (fear proxy) reduced by careful micro-handling in both methods [45]	↓ in UP, lower agitation and better catcher–bird interaction [47, 49]	-
Birds per drawer/stocking density	↑ higher density increases DOA/injury risk [58]	-	↓ in UP, slightly lower birds per drawer [48]	↓ more consistent drawer densities under MECH [56]
Machine bumps/flips	-	-	-	↑ bumps and flips predict haematomas and fractures [39]
Conveyor/rotor speed (machine setting)	-	-	-	↑ higher speed increases flapping/bumps/flips and lesions; ↓ slow speed reduces injuries [50, 51]
Container type/interface (GP vs SmartStack)	-	-	-	mixed: ↑ escape/flapping/bumps-into-birds with SmartStack but ↓ bumps-against-machine; injuries follow these impacts [50, 51]
Drawer position (low vs mid vs high)	↑ of epiphyseolysis/haematomas in low drawers [45]	-	-	-
Ambient temperature/season	↑ DOA and bruising by thermal stress and season effect [52, 58]	-	-	↑ more impacts/flapping and some lesions in autumn; season modifies MECH outcomes [50, 57]

Table 2 (continued)

Parameter	General effects of depopulation 	One (ONE)-leg vs. two-leg (TWO) catching  vs. 	Upright (UP) vs. inverted (IV) catching  vs. 	Manual (MAN) vs. machine (MECH) catching  vs. 
Body weight/weight class	↑ wing lesions and stronger stress responses in heavier broiler chickens [42, 46]	↑ higher weight (OR = 3.6 [46])	UP advantages particularly relevant in heavy/handling-sensitive flocks [47, 48]	Method effects vary with weight and machine interaction [39, 56]
Catching/loading duration (process time)	↑ longer catching/transport/lairage increases DOA/injury risk [52, 58] ↑ risk of haematomas with higher loading duration (1.5% [45])	↓ in ONE (22–35 min. per container vs. 30–65 min per container [46])	↑ in UP [47] ↓ in UP (252 vs. 231 s per module [48]) ↑ in UP, agitation increases toward last loading hour [49] ↑ in UP [47, 49]	↑ labour time in MAN [47, 54, 59] — duration not a major driver in tested system [56]
Crew size/fatigue	↑ poor crew choice/training increases injuries [52]	↓ careful micro-handling reduces fear/injury in both 1- and 2-leg methods [45]		↓ in MAN more workers per 10k birds reduces haematomas; MECH less fatigue-sensitive [56]
Ergonomics/cost trade-off	↑ depopulation is ergonomically demanding [59]	-	↑ UP more labour-intensive/costly than inverted [47]	↓ best ergonomics and lowest labour in MECH [47, 54]

↑ stands for increasing, ↓ stands for decreasing, = indicates no difference, and - not assessed

bruising of wingtips or breast, leg bruises or fractures, or for the overall prevalence of injured hens.

However, upright catching required substantially more time, with an increase of approximately 70% (1.7 times longer) compared with inverted catching (8.2 ± 3.2 vs. 4.8 ± 2.0 person-hours per 1,000 hens; $p = 0.011$), indicating higher labour demands. Average labour costs for upright catching were approximately 1.8 times higher than for inverted catching (369.4 € vs. 206.5 € per 1,000 hens), corresponding to additional costs of around 3,478 € for a flock of 20,000 laying hens. Based on a questionnaire completed after the loading trials, most catchers perceived upright catching to be strongly (45%) or moderately (45%) more tiring than inverted catching, while nearly half perceived no difference in hen behaviour between the two methods (47%).

Welfare aspects of catching and loading of broiler chickens – scientific studies

Research on the catching and loading of broiler chickens has been conducted since the early 1960s, initially focusing on carcass quality and economic outcomes. More recent experimental and field studies have increasingly examined welfare-related consequences of different handling practices.

Table 2 synthesises these findings by juxtaposing catching methods and reported outcomes across studies, thereby providing a structured basis for the subsequent discussion.

General effects of inverted catching of broiler chickens

In line with slaughterhouse condemnation priorities, early abattoir-based studies primarily focused on reasons for carcass rejection. These investigations consistently showed that the majority of bruises originated within the last 24 hours before slaughter and were therefore attributable to pre-slaughter handling rather than housing conditions [60–62]. However, because injuries were assessed at the slaughterhouse, these studies generally did not allow a clear distinction between injuries sustained during catching, loading, transport or unloading. Bruising was predominantly located on the breast, legs, and wings [63–65].

In conventional manual catching by the legs with birds carried in an inverted position, welfare research has primarily focused on bruising, fractures, fear-related behaviour and short-term stress physiology. Wilson and Brunson [43] demonstrated that injury incidence during manual catching is strongly influenced by the handling process itself: gentle catching followed by CO₂ immobilisation eliminated haemorrhaging, indicating that bird agitation and uncontrolled wing flapping during inversion are proximate causes of bruising. Subsequent studies confirmed that catching represents a

principal origin of wing trauma when inverted handling is applied. Using sequential tracking of birds, Jacobs et al. [52] observed a sharp increase in wing fracture prevalence of approximately 1.8% immediately after catching and prior to transport, thereby identifying catching crews and handling practices as key modifiable risk factors. Fractures were assessed using the Welfare Quality® protocol and only fractures associated with visible bruising were classified as fresh. Inverted catching remains consistently associated with fear-related struggling and impact injuries. Perretti and Weimer [66] demonstrated experimentally that fear responses during inversion depend strongly on the point of restraint. Broiler chickens held by the feet exhibited markedly more righting attempts and wing flapping than birds held by the shanks (mean number of responses: 23.78 vs. 8.10), indicating substantially greater agitation when distal restraint is applied.

One-leg vs. two-leg catching of broiler chickens

Langkabel et al. [46] reported wing lesions in 15.32% of broiler chickens when assessed after the plucking stage in the abattoir. When comparing routine one-leg inverted catching (two to three birds per hand) with a two-leg inverted variant (up to two birds per hand), their data revealed virtually no effect of catching method on injury prevalence. Instead, body weight (light animals about 1.9 kg, heavy animals about 2.5 kg at final depopulation) emerged as by far the strongest predictor of wing injury risk. These findings suggest that, within inverted leg-catching practices, welfare differences between minor technical variants are small relative to overall flock susceptibility to injury and individual live weight. This further emphasises that handling-related welfare risks in broiler chickens cannot be fully addressed without considering production-related factors such as growth rate and body conformation.

More broadly, comparisons between one-leg and two-leg grasping within manual catching have yielded mixed but informative results regarding welfare relevance. Langkabel et al. [46] reported no meaningful differences in lesion prevalence between one-leg and two-leg inverted catching, with higher body weight emerging as the dominant predictor of injury risk irrespective of technique. In addition, two-leg catching was associated with longer catching times (22–35 min for one-leg catching vs. 30–65 min for two-leg catching, across the different comparisons, each conducted under the same conditions that differed in weight class and number of containers filled) and increased restlessness and wing flapping during the catching process, potentially offsetting theoretical benefits related to greater body stability. In contrast, Wessel et al. [45] observed higher levels of wing flapping and significantly more severe wing injuries under one-leg catching

compared with two-leg catching during 12 loadings with behavioural observations of 100 randomly selected broilers per method (200 per loading) and post-loading clinical examinations of 5,624 broilers in total.

Importantly, these studies showed that careful micro-handling elements—such as short grasping duration, settling birds into crates, and avoiding crate strikes—reduced wing flapping under both catching methods, while injury risk increased with longer catching durations and when birds were placed in the lowest crate tiers compared with middle and upper tiers. Taken together, the available evidence suggests that two-leg grasping may offer welfare advantages in some contexts, particularly with respect to reducing severe wing injuries, when it is executed cleanly and efficiently. Nevertheless, welfare differences between one-leg and two-leg manual catching appear to be relatively small.

Upright vs. inverted catching of broiler chickens

Manual upright catching, typically performed by supporting birds under the abdomen and carrying them in a natural body orientation, has been evaluated as a welfare-improving alternative to inverted handling. In a study of 3,951 broilers from two flocks, Kittelsen et al. [48] reported that upright catching reduced module-fill time, resulted in a more consistent number of birds per drawer, and showed a tendency towards fewer wing fractures compared with inverted leg carrying (0.005% of 19,417 transported birds vs. 0.05% of 2,010 examined birds, $p=0.06$), without any observed increase in dead-on-arrival rates. Behavioural analyses likewise favour upright methods. De Lima et al. [49] identified specific upright handling practices—catching one bird at a time, containing the wings, and minimising collision risk at the crate entrance—as significantly reducing agitation both in the catcher's hands and during crating. In addition, they documented a fatigue-related gradient, with video analyses showing increasing agitation towards the final loading hour, suggesting that upright catching may buffer welfare particularly by limiting vigorous wing flapping and impact injuries as catcher fatigue increases.

The most direct commercial three-method comparison to date, conducted by Delanglez et al. [47], confirmed that upright manual catching reduced wing flapping (mean score: 2.0 vs. 5.4 on a 7-point scale, where 1 represented the lowest and 7 the highest wing-flapping frequency while the bird was held by the catcher, $p<0.001$). However, upright catching was slower and more labour-intensive, indicating a clear trade-off: measurable welfare benefits are achieved at the cost of increased time, labour and logistical demands. Across studies, the welfare advantage of upright catching therefore appears robust at the behavioural level, reflected by reduced wing flapping and calmer handling, and is supported by trends towards

fewer wing injuries. Nevertheless, upright catching takes longer, the effect sizes vary and are strongly influenced by crew skill, handling efficiency and operational constraints.

Manual vs. machine catching of broiler chickens

Mechanical catching systems have been compared with manual methods using a range of welfare indicators, including injuries, fear-related behaviour, and physiological responses, with results indicating conditional rather than uniform welfare effects. Early experimental and field studies suggested potential advantages of mechanical systems. Duncan et al. [44] used radiotelemetry for heart rate and TI duration in 1,000 8-week-old broilers to show that machine and manual catching elicited similarly high peak heart rates; however, mechanically caught birds recovered more rapidly and exhibited markedly shorter TI durations, indicating lower fear responses. Berry et al. [67] compared the AFRC Mark I harvester with conventional hand catching in commercial broiler houses and found that mechanically harvested birds recovered more rapidly from the post-catching increase in heart rate, indicating lower short-term stress while maintaining commercial harvesting rates. In addition, Lacy and Czarick [68] described comparable or lower overall bruising rates with mechanical rotor harvesters, with leg and hock bruising reduced by approximately 50% compared with conventional inverted hand catching. In a study by Knierim and Gocke [55], where a total of 40 manual and 43 mechanical depopulations were examined, the injury rate was significantly reduced in mechanical catching ($p<0.05$) whereas the dead-on-arrival rate was not affected ($p=0.07$). Over one year, a total of 869,738 and 1,112,419 birds (Cobb and Ross hybrids, 31–35 days old with weights of 1.300–1.750 g) were caught manually and mechanically, respectively. For mechanical catching the 'Chicken Cat' (Jydsk Transport Teknik, Denmark) was used. At the slaughterhouse, about 10% of the birds were examined.

Subsequent studies by Delezie et al. [41] and Nijdam et al. [38] concluded that, when properly operated, mechanical catching can be compatible with animal welfare and may reduce direct human handling and fear responses. However, Nijdam et al. [38] also reported a slightly higher dead-on-arrival rate in spring, highlighting the influence of seasonal and operational factors. More recent high-resolution studies have further complicated this picture by identifying machine-specific injury pathways. Wolff et al. [39] confirmed significantly more wing flapping during manual compared with mechanical catching (OR = 2.11, $p<0.05$), with 68.6% of manually caught broilers showing wing flapping. However, they also showed that impacts, bumps and flips within the harvester increased the risk of haematomas and fractures. Mönch et al. [56] reported

fewer wing haematomas under manual catching than with a tested Apollo harvester, as well as a higher dead-on-arrival rate following mechanical loading, indicating that welfare outcomes may reverse when machine settings or bird-machine interfaces are suboptimal. Large-scale Dutch slaughterhouse datasets similarly associated mechanical catching with higher dead-on-arrival rates and total carcass rejection compared with manual catching, without clear reductions in wing haematomas [57]. Mechanisation-focused studies help explain these divergent findings: Werner et al. [50] and Unterholzner et al. [51] demonstrated that factors such as increased rotor and conveyor speeds, collisions, flips and interactions with containers predict lesion risk, while container design and season further modulate these effects. Direct comparisons between mechanical and upright manual catching are scarce. However, Delanglez et al. [47] reported a lower prevalence of catch damage in upright than in mechanical catching ($15.5 \pm 1.3\%$ vs. $17.7 \pm 1.4\%$; $p=0.046$), indicating that mechanisation does not necessarily improve all welfare outcomes. Taken together, these studies indicate that mechanical catching can reduce fear-related struggling relative to inverted manual catching, but that any welfare advantage is highly sensitive to machine design and operational settings. Poorly adjusted systems may increase haemorrhages or dead-on-arrival rates, whereas well-tuned systems can reduce fear responses and certain types of injury.

Respiratory effects of catching and loading: critical appraisal of evidence

EFSA [1] characterises inversion as a hazard, stating that, because birds lack a diaphragm, inverted handling “can provoke compression of the heart and lungs by the viscera and might compromise breathing and cardiac activity”. However, this proposed mechanism is not supported by direct empirical evidence. None of the studies identified in this review assessed ventilation parameters, blood gases, or cardiac output in chickens held in an inverted position, and EFSA does not cite a primary experimental source for this assumption. From an anatomical and functional perspective, substantial compression of the avian lungs by the viscera appears unlikely. The avian lung is relatively rigid and firmly attached dorsally to the ribs and vertebrae, while ventilation is achieved primarily through movements of the sternum and rib cage and the expansion of the air sacs. These structural characteristics limit deformation of the lung parenchyma itself. Instead, respiratory restriction is more plausibly associated with external mechanical constraints on thoracic excursion, such as pressure applied to the rib cage or sternum during restraint. Such constraints may occur during handling in both inverted and upright positions, particularly when birds are held tightly or when multiple hens are

carried simultaneously, requiring a firm grip to prevent escape or falling.

The available studies reporting increased respiratory rates during depopulation (e.g. [34]) do not allow conclusions to be drawn regarding the underlying physiological mechanism. Elevated respiration may reflect a stress-related sympathetic response or an attempt to regain balance rather than impaired ventilation resulting from visceral compression. Similarly, higher wing-flapping frequencies observed in inverted hens [35] may indicate increased discomfort, but could also arise from greater freedom of movement, as wings are typically restrained during upright carrying. To date, no study in broiler chickens has provided direct physiological measurements of ventilation under inverted handling. However, behavioural indicators such as struggling, righting attempts, and wing flapping during inverted manual catching were frequently observed. Findings by Wessel et al. and Perretti and Weimer [45, 66] suggest that any increase in respiratory effort is more plausibly linked to stress-induced muscular activity and balance correction than to visceral compression. In line with this interpretation, mechanical catching systems, which eliminate inversion, are often associated with reduced wing flapping and shorter TI durations [41, 44], indicating lower fear-related responses. Taken together, the evidence suggests that inverted catching reliably elicits stronger stress reactions, but that the frequently proposed physiological mechanism, compression of the heart and lungs by the viscera, remains speculative and is not directly supported by empirical data. Future studies should therefore include direct measurements of ventilation, thoracic mechanics and gas exchange across different handling positions to clarify the respiratory consequences of catching and loading practices.

Heterogeneity of study designs and implications for comparability

A major limitation of the current evidence base is the substantial heterogeneity in study designs. Early investigations focused predominantly on fractures and TI as outcome measures [30–32], whereas more recent studies expanded their scope to include physiological variables such as corticosterone concentrations, respiratory rate, surface temperatures and creatine kinase activity [34]. Protocols varied widely with regard to sample size, number of farms, catching personnel and recording methods, which substantially limits direct comparison across studies. Moreover, the indicators used reflect different dimensions of animal welfare. Endocrine markers capture acute systemic stress responses but are highly sensitive to sampling timing; injury-based indicators primarily reflect physical damage and associated pain, whereas TI tests are intended to assess fearfulness but

are strongly influenced by handling prior to testing. In addition, some studies assessed birds at a single time point, whereas others applied repeated measurements (e.g. [34]), further constraining comparability. As a result, these methodological inconsistencies make it difficult to draw universally valid conclusions regarding the superiority of specific catching methods. Instead, the existing literature provides fragmented insights into distinct physiological and behavioural responses. Compared with studies in laying hens, investigations in broiler chickens introduce additional methodological complexity. Large flock sizes, higher body weights and the widespread use of mechanical harvesting systems add further variables, including conveyor speed, machine-induced impacts and interactions with transport containers, all of which directly influence injury risk [39, 50]. Many studies on broiler chickens rely on slaughterhouse-based scoring of haemorrhages and fractures; however, the timing of these assessments varies considerably (e.g. after catching, post-transport or post-chilling), complicating causal attribution [53]. Furthermore, comparisons between one-leg and two-leg inverted catching often reveal small or inconsistent effects [45, 46], emphasising that micro-handling quality and execution frequently outweigh nominal differences in catching technique. Mechanical catching studies add further confounders, such as machine type, rotor speed, container design and season, making cross-study comparisons particularly challenging.

Future studies would benefit from harmonised welfare assessment protocols. At a minimum, injury-related outcomes (i.e. fractures, dislocations, haematomas and mortality) should be assessed using standardised definitions and reporting criteria. Behavioural and physiological indicators should be measured using comparable protocols, particularly regarding the timing of observations and sample collection. Furthermore, studies should clearly distinguish between short-term stress responses, injury-related outcomes and longer-term welfare consequences.

Interpretation for laying hens: welfare indicators and practical relevance

Despite substantial methodological variability across studies, several consistent patterns emerge in relation to welfare outcomes in laying hens. Injury data repeatedly indicate that inverted catching and one-leg handling are associated with an increased risk of fresh fractures and wing haematomas [31, 35]. Physiological indicators, including elevated respiratory rates, increased corticosterone concentrations, and alterations in surface temperature, are likewise consistent with inverted handling representing a stronger acute stressor [34]. In contrast, behavioural fear responses such as TI often show smaller or inconsistent differences between catching

methods. Importantly, the relationship between animal-based welfare outcomes and practical feasibility is not straightforward. Upright catching may reduce injury risk but is substantially more labour-intensive and time-consuming than inverted catching [35], thereby increasing ergonomic strain and fatigue among catching crews. In addition, upright handling may prolong the overall catching process, potentially extending the duration of background stress experienced by the birds. This background stress arises from sustained exposure to human presence, noise, and movement during depopulation. Consequently, short-term stress responses associated with specific handling techniques need to be interpreted in conjunction with the potential welfare implications of a longer, lower-intensity stress period. Under commercial conditions, the choice of catching method is therefore shaped not only by animal welfare considerations, but also by practical constraints such as barn layout, workforce availability, and time pressure during depopulation. Moreover, several studies emphasise that the act of catching and carrying birds itself, irrespective of the specific method employed, constitutes a major stressor. Handling by unfamiliar individuals, physical restraint, loss of footing, and removal from the social group elicit pronounced physiological and behavioural responses. In this context, method-related differences, although demonstrable, may represent incremental variations superimposed on a generally high level of handling-related stress. This pattern mirrors findings in laying hens, underscoring that execution quality, fatigue management and organisational conditions strongly modulate welfare outcomes alongside the nominal catching method. Although these principles may be broadly relevant across poultry species, their application to broiler chickens requires careful consideration of important biological and management-related differences.

Interpretation for broiler chickens: welfare indicators and practical relevance

In broiler chickens, inverted leg catching is consistently associated with increased wing flapping, fear-related struggling and a higher risk of wing haemorrhages and fractures [52, 53]. Upright manual catching reduces agitation and tends to decrease catching-origin wing injuries [47–49], albeit at the cost of slower throughput and increased labour demands, closely paralleling findings in laying hens. Mechanical catching systems can reduce fear-related behaviour relative to inverted manual catching [41, 44]. However, injury outcomes are highly variable and depend strongly on machine settings, bird–machine interfaces, and crew operation [39, 56, 57]. Field evidence further suggests that the welfare consequences of inverted catching often become more apparent at slaughter, although causal attribution depends on the timing

of injury assessment [53]. Injuries recorded only after transport or chilling may dilute observable differences between catching methods, whereas assessments conducted closer to the catching event more consistently identify inverted handling as a risk factor for wing haemorrhages and fractures. These findings underscore the importance of considering when and where welfare indicators are measured along the production chain. Overall, broiler studies reinforce two general principles also observed in laying hens. First, inversion reliably increases fear responses and injury risk. Second, techniques that avoid inversion may improve welfare outcomes. However, whereas upright manual catching is generally associated with increased labour requirements and longer catching times, mechanical systems may improve labour efficiency but show more variable welfare outcomes depending on machine design and operation. As in laying hens, differences between specific manual technique variants within inverted catching (such as one-leg versus two-leg grasping) are frequently small or inconsistent once body weight, handling quality and operational context are taken into account. Consequently, in broilers, as in laying hens, the orientation of the bird and the degree of restraint appear to be more influential determinants of welfare than fine-grained differences in catching technique.

Practical and methodological considerations

Although upright catching generally results in fewer fractures and wing injuries in laying hens compared with inverted and one-leg catching [31, 35], this method is substantially more labour-intensive and time-consuming with a potentially greater physical workload for catchers. EFSA likewise describes the catching, crating, and loading of end-of-lay hens – particularly in multi-tier systems – as highly labour-demanding and ergonomically challenging [1]. Catching techniques that are more favourable for the birds may therefore simultaneously impose greater burdens on workers, highlighting a structural tension between animal welfare objectives and operational constraints. Catchers frequently work on elevated tiers, may need to maintain their balance while handling birds, and often have restricted access to hens located behind structural elements, perches, or other birds, sometimes leaving only one hand available for handling. These conditions may also increase the risk of slips, trips, and falls during depopulation and can make individual upright catching considerably more demanding under commercial conditions than is apparent from comparisons of handling time alone.

In broiler chickens, practical constraints differ because birds are caught directly from the floor. Depopulation therefore involves a large number of repetitive bending and lifting movements, which contribute substantially to

the physical workload of catching crews. Catching birds individually in an upright position may further increase the number of these repetitive movements compared with handling several birds simultaneously, thereby creating additional ergonomic challenges. Additionally, longer loading times may prolong waiting times in transport containers, complicate the coordination of feed withdrawal and transport schedules, and potentially increase exposure to thermal and handling-related stress. The most direct way to avoid this is to assign more staff to catch and load the animals within a comparable amount of time. The biological relevance of observed differences between catching methods depends on the indicators used. Physiological changes such as moderate increases in respiratory rate, corticosterone concentration or surface temperature [33, 34] reflect acute stress responses, but their welfare relevance is difficult to assess in the absence of clinical consequences. In contrast, even relatively small differences in fracture or haematoma prevalence are likely to be of high welfare relevance, given the pronounced bone fragility of end-of-lay hens and the high baseline prevalence of keel and limb damage [13, 14]. Interpreting findings solely on the basis of statistical significance may therefore be misleading; practical and biological relevance should be considered explicitly. Mechanical catching systems can reduce fear responses compared with inverted manual catching, but their welfare performance depends heavily on machine speed, shock exposure, crate interface, and operator skill; poorly adjusted systems may increase haematomas or dead-on-arrival rates [39, 56, 57]. Across both production types, ergonomic improvements that reduce carrying distances, rushing, and fatigue may support better welfare outcomes by enabling calmer and more precise handling. The interpretation of individual studies is further complicated by methodological heterogeneity. Endocrine stress markers such as corticosterone are strongly influenced by the timing of blood sampling and may reflect cumulative effects of catching, crating and transport rather than a specific handling step [33]. Behavioural indicators such as TI can be altered by pre-test handling and individual fearfulness [32], while creatine kinase provides only a non-specific indication of muscular strain [34]. EFSA [1] further emphasises that stocking density, barn design, and environmental conditions act as confounding factors during catching and loading. Together, these limitations constrain the strength of inferences that can be drawn from direct comparisons of catching methods. Multiple studies indicate that gentle, controlled handling reduces fear responses and agitation [30, 32], and Delanglez et al. [35] report significant differences in handling quality scores between catching crews and methods. EFSA [1] likewise stresses that rushed, uncoordinated catching and inadequate training increase the likelihood of trauma, whereas

calm and deliberate handling mitigates stress. Providing sufficient time, appropriate lighting and clear workflows, together with training in species-specific handling, therefore appears essential for welfare-oriented depopulation, regardless of the catching method employed. Measures that reduce physical strain - such as positioning containers closer to the birds, using wheeled dollies or adapting barn preparation to facilitate access - can decrease carrying distances and effort, thereby enabling calmer and more precise handling [1, 35]. In this sense, work-friendly practices may also be animal-friendly, not because they eliminate the intrinsic stressfulness of catching, but because they reduce fatigue, haste, and the risk of handling errors.

Summary of major findings

This scoping review reveals that only a limited number of scientific studies have examined the welfare implications of specific catching and loading methods in laying hens. Across these studies, a heterogeneous set of welfare indicators - including physiological, behavioural, and injury-related parameters - has been used, substantially limiting direct comparability. Nevertheless, consistent tendencies emerge. Upright catching is generally associated with fewer injuries and lower corticosterone concentrations [30], whereas depopulation as such elicits pronounced physiological stress responses, including increased corticosterone concentrations, respiratory rate and changes in surface temperature (e.g. [34]). Some studies further report higher wing-flapping frequencies and a greater prevalence of wing haematomas during inverted handling [35]. Intervention studies, including trolley loading and modified lighting, did not demonstrate measurable improvements in welfare outcomes [37]. Overall, the evidence reveals recurring patterns, although it remains constrained by methodological heterogeneity.

Conclusion

Overall, the available evidence suggests that catching methods associated with reduced agitation, fewer collisions, and lower handling-related trauma tend to result in improved welfare outcomes. Although upright catching is frequently associated with lower wing-flapping frequencies and, in some studies, reduced injury prevalence, the available evidence does not always allow these effects to be separated from differences in restraint and handling technique. Consequently, conclusions regarding the specific welfare effects of body orientation should be interpreted with caution. Across studies, welfare risks during catching and loading appear to arise primarily from fear-related struggling, loss of balance and handling-related trauma rather than from any single catching technique itself. The most consistent evidence therefore supports handling practices that minimise bird agitation,

collisions, and physical injury, irrespective of the specific catching method employed. Future research should simultaneously assess animal welfare outcomes, labour requirements, ergonomic workload and economic costs, as these factors jointly determine the practical feasibility and sustainability of alternative catching methods. Future alternative catching methods should increasingly incorporate tools and technologies to further reduce both the workload for catchers and the stress on the animals. In general, greater methodological standardisation would further improve comparability between studies and strengthen the evidence base for welfare-oriented catching and loading practices.

Supplementary Information

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Supplementary Material 1

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Author contributions

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Ethics approval and consent to participate

Not applicable. The research was conducted without human or animal participants and did not require such approval.

Consent for publication

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Competing interests

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