

Transport-related pig mortality: Synergistic effects of travel distance and seasonEva Justová¹, Vladimír Večerek¹, Zbyněk Semerád², Michal Kaluža¹,
Michela Maria Dimuccio³, Eva Voslářová¹¹University of Veterinary Sciences Brno, Faculty of Veterinary Hygiene and Ecology,
Department of Animal Protection and Welfare and Veterinary Public Health, Brno, Czech Republic²Central Veterinary Administration of the State Veterinary Administration, Prague, Czech Republic³University of Bari Aldo Moro, Department of Veterinary Medicine, Valenzano, Italy

Received February 23, 2026

Accepted May 4, 2026

Abstract

This study aimed to assess the potential synergistic effect of season and transport distance on mortality rates in pigs transported to slaughterhouses in the Czech Republic between 2017 and 2023. A retrospective analysis was conducted using data from all pig transports under official veterinary supervision during the monitored period. Transport-related mortality was evaluated in sows ($n = 348\ 141$), piglets ($n = 97\ 785$), and finishing pigs ($n = 15\ 821\ 391$). Mortality was significantly influenced by both season and transport distance in all pig categories ($P < 0.05$). The highest mortality rates occurred during summer, with the most unfavourable combination being summer and very long transport distances (> 300 km) in sows (1.34%) and finishing pigs (0.51%). In piglets, the most critical combinations were summer with long distances (101–200 km: 1.52%; 51–100 km: 1.05%). Mortality was consistently lowest in winter and at short transport distances (≤ 50 km). These findings confirm a synergistic effect of heat stress and transport duration on pig mortality. This large-scale national dataset highlights the need for species- and category-specific transport guidelines, particularly during hot weather and longer journeys. Reducing journey length during summer and improving transport conditions are essential to improve animal welfare and reduce economic losses.

Meat industry, farm animals, welfare, DOA, Sus scrofa f. domestica

Transport of pigs to slaughterhouses is a critical phase in the production chain that poses significant welfare challenges. The combination of handling, loading, transport conditions, and unloading exposes pigs to multiple stressors, including temperature extremes, vibration, social mixing, and feed and water deprivation, which can adversely affect their health and survival (Grandin 1997; Warriss 1998; Averos et al. 2008; Nielsen et al. 2011; Schwartzkopf-Genswein et al. 2012). Transport-related mortality is a severe outcome reflecting these cumulative stresses and serves as an important welfare indicator, while also causing economic loss for producers (Haley et al. 2008; Marti et al. 2022).

Physiologically, pigs respond to transport stress through activation of the hypothalamic-pituitary-adrenal axis, resulting in elevated cortisol levels and changes in heart rate and metabolism (Goumon et al. 2013; Rioja-Lang et al. 2019; EFSA AHAW Panel 2022). These responses can impair immune function and thermoregulation, increasing susceptibility to mortality, particularly under extreme environmental conditions (EFSA AHAW Panel 2022). Heart failure has been identified as a primary cause of in-transit mortality (Zurbrigg et al. 2021), with cardiac abnormalities being the most consistent pathological findings in deceased animals (Zurbrigg et al. 2017), suggesting a possible link between transport-induced physiological stress and cardiac collapse.

Transport duration and distance can influence the extent to which pigs are exposed to potential stressors during the journey. However, the relationship between journey length

Address for correspondence:prof. Ing. Eva Voslářová, Ph.D.
Department of Animal Protection and Welfare and Veterinary Public Health
Faculty of Veterinary Hygiene and Ecology
University of Veterinary Sciences Brno
Palackého tř. 1946/1, Brno 612 42, Czech RepublicE-mail: voslarovae@vfu.cz
<https://actavet.vfu.cz/>

and adverse welfare outcomes is complex and non-linear, with studies reporting varying effects depending on environmental conditions and other contributing factors. Some studies have reported increased mortality rates associated with longer transport durations (Voslářová et al. 2017; Dalla Costa et al. 2019; Romero et al. 2022), whereas others have found no significant effects (Kephart et al. 2010; Marti et al. 2022)—or even higher mortality rates associated with shorter journeys (Sutherland et al. 2009)—highlighting the multifactorial nature of transport-related welfare risks.

Interactions between season and transport distance—i.e., their potential synergistic effects—have rarely been evaluated in pigs. In our recent research on poultry, we found that the combination of extreme seasonal temperatures and long transport distances significantly increased mortality. However, the results varied by species and category. For laying hens and broilers, winter transport over very long distances was particularly critical. In contrast, for ducks, peak mortality occurred during summer transport over longer distances (Justová et al. 2025a). A similar synergistic pattern was observed in cattle: in cows, winter combined with the longest transport distances resulted in the highest mortality rates, whereas other cattle categories showed no such interaction (Justová et al. 2025b). Comparable combined effects have also been reported in rabbits, in which the highest mortality occurred during long-distance transport in spring, further highlighting species-specific differences in seasonal vulnerability (Lakomá et al. 2025).

Current European legislation—specifically Regulation (EC) No 1/2005 (Council of the European Union 2005)—sets standards for animal transport, including requirements for vehicle design, limits on journey duration, rest periods, and temperature control, with the aim of minimizing welfare risks. However, these rules primarily address individual factors without fully considering the interaction between environmental conditions and journey length, which recent scientific opinions highlight as areas needing further study (Padalino et al. 2018; EFSA AHAW Panel 2022).

Moreover, previous research has mainly focused on finishing pigs, which constitute the largest transported group; however, sows and piglets—with their distinct physiological and behavioural characteristics—may respond differently to transport stress (Ríoja-Lang et al. 2019; Válková et al. 2022). For example, piglets are more sensitive to temperature fluctuations due to their immature thermoregulation (Gomez-Prado et al. 2022), whereas sows may be more affected by prolonged journeys due to their body condition and age (Grandin 2016; Fogsgaard et al. 2018).

The aim of this study was to assess the potential synergistic effect of season and transport distance on the number of pigs that died during transport to slaughterhouses in the Czech Republic.

Materials and Methods

This study was based on retrospectively collected data from official veterinary inspections of pig transport to slaughterhouses in the Czech Republic between 2017 and 2023. The analysis included all consignments of live pigs transported from Czech farms to any slaughterhouse within the country during the study period. Transport was conducted exclusively by road using trucks specifically designed for the carriage of pigs. All transport journeys adhered to Council Regulation (EC) No 1/2005 on the protection of animals during transport and related operations (Council of the European Union 2005).

The transport of pigs was evaluated according to three categories: sows (348 141 animals), piglets (97 785 animals), and finishing pigs (15 821 391 animals). The number of pigs transported during the monitored period, broken down by category, season, and transport distance, is presented in Table 1.

To evaluate the effect of season, the year was divided into four periods: spring (March, April, and May), summer (June, July, and August), autumn (September, October, and November), and winter (December, January, and February). The average seasonal temperatures recorded by the Czech Hydrometeorological Institute during the monitored period were 8.2 °C in spring, 18.6 °C in summer, 9.2 °C in autumn, and 0.5 °C in winter.

Transport distances were categorized based on the geographical context of the Czech Republic, a country with a total area of approximately 78 866 km² and a maximum east–west distance of about 493 km. Accordingly,

five transport distance categories were defined: very short distance (up to 50 km), short distance (51–100 km), medium distance (101–200 km), long distance (201–300 km), and very long distance (over 300 km).

The mortality rate was assessed for each pig category transported to slaughterhouses. Relative mortality rates over the entire monitoring period were compared between seasons to determine the effect of season on pig mortality during transport. Similarly, relative mortality rates were compared across transport distance categories to evaluate the effect of transport distance on transport-related pig mortality. Furthermore, relative mortality rates were assessed for each combination of season and transport distance to identify which combinations of these two factors resulted in the highest mortality for each pig category transported to slaughterhouses.

The data were analysed using Unistat v. 6.5 (Unistat Ltd., London, UK). Statistical evaluation was based on comparisons of relative frequencies using chi-square (χ^2) test, with statistical significance set at $P < 0.05$.

Table 1. Number of transported pigs by category, season, and transport distance.

Category	Season	Transport distance				
		≤ 50 km	51–100 km	101–200 km	201–300 km	> 300 km
Sow	Spring	30 814	23 833	29 227	6 745	260
	Summer	28 457	22 218	28 236	7 179	372
	Autumn	29 271	23 241	28 312	6 760	272
	Winter	28 171	20 877	27 317	6 319	260
Piglet	Spring	13 857	5 593	4 720	111	0
	Summer	18 267	6 124	3 219	55	0
	Autumn	12 893	6 337	5 076	64	0
	Winter	10 533	5 547	5 293	96	0
Finishing pig	Spring	1 692 851	1 074 733	1 006 037	296 893	15 368
	Summer	1 583 624	1 025 661	990 341	287 607	13 552
	Autumn	1 635 586	1 049 501	998 498	301 779	12 896
	Winter	1 584 805	1 013 174	942 229	281 242	15 014

Results

Figure 1 presents transport-related mortality rates of sows, piglets, and finishing pigs across different seasons, regardless of transport distance. The results demonstrate a significant effect of season on pig mortality during transport to slaughterhouses. Across all categories, mortality rates were highest during the summer, while significantly lower ($P < 0.05$) mortality was observed in the other seasons. The lowest mortality rates were recorded in winter for sows and finishing pigs, and in autumn for piglets.

Figure 2 presents transport-related mortality rates of sows, piglets, and finishing pigs in relation to transport distance, irrespective of season. The results indicate a significant effect of transport distance on pig mortality during transport to slaughterhouses ($P < 0.05$). For sows, the highest mortality rates were observed during transport over 300 km, followed by lower rates at distances between 51–300 km, and the lowest mortality at distances up to 50 km. In piglets, higher mortality was recorded at transport distances between 51–200 km, while the lowest mortality occurred at distances up to 50 km. Transport over 201–300 km was rare in piglets, and no transports over 300 km were recorded for this category. For finishing pigs, the highest mortality was observed during transport over 300 km, followed by significantly lower mortality at 101–200 km. Even lower mortality rates were recorded at 51–100 km and 201–300 km, with no significant difference between these two categories. The lowest mortality occurred at transport distances up to 50 km.

Figure 3 illustrates the synergistic effect of season and transport distance on transport-related mortality in sows. The highest mortality in sows (1.34%) was observed with the combination of summer and very long transport distances (> 300 km). In piglets (Fig. 4), the most unfavourable combinations were summer with long distances, particularly

101–200 km (1.52%) and 51–100 km (1.05%). These combinations were associated with the highest mortality rates in this category. For finishing pigs (Fig. 5), the highest mortality (0.51%) was also recorded during the summer season combined with very long transport distances (> 300 km), confirming a strong interaction between high ambient temperatures and prolonged transport duration.

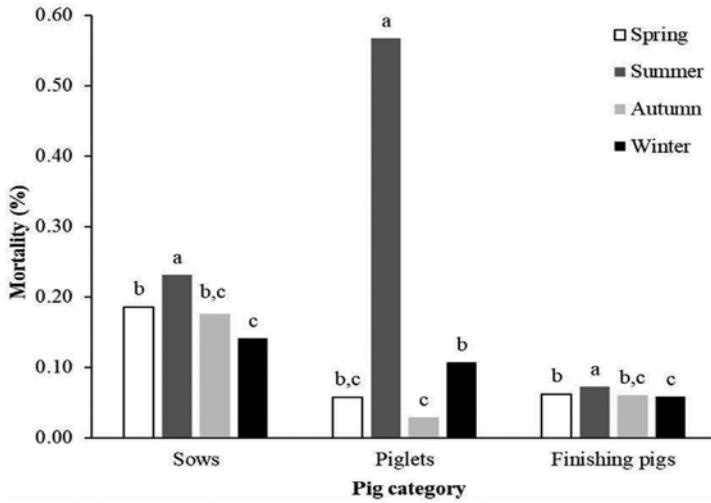


Fig. 1. Transport-related mortality rates of sows, piglets, and finishing pigs by season in the Czech Republic during the period 2017–2023

Different letters above columns within the same pig category indicate significant differences in mortality rates ($P < 0.05$)

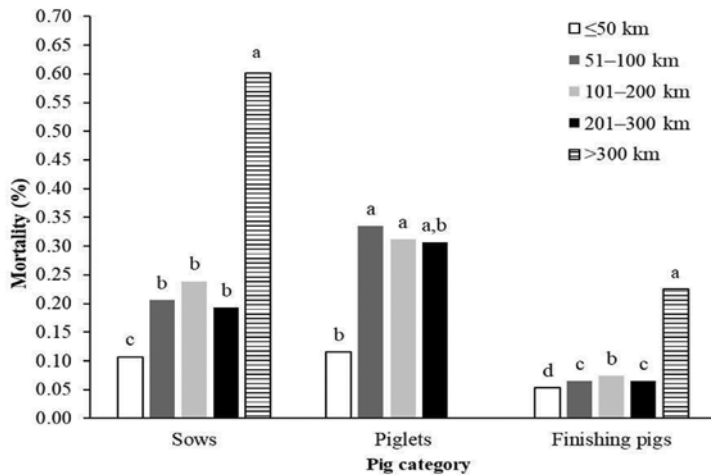


Fig. 2. Transport-related mortality rates of sows, piglets, and finishing pigs by transport distance in the Czech Republic during the period 2017–2023

Different letters above columns within the same pig category indicate significant differences in mortality rates ($P < 0.05$)

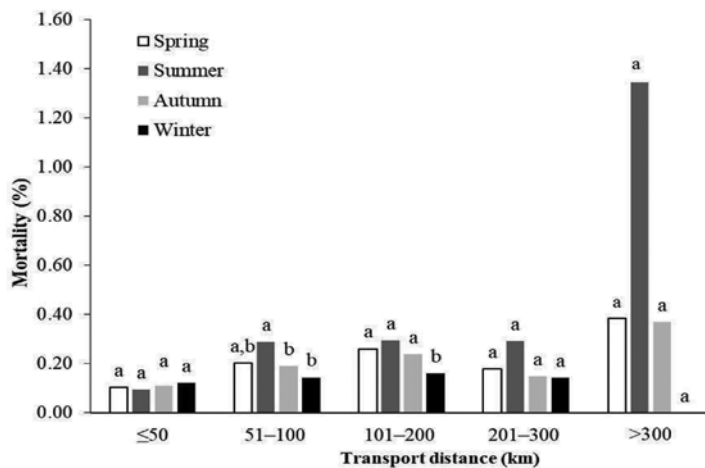


Fig. 3. Transport-related mortality rates of sows by season and transport distance in the Czech Republic during the period 2017–2023

Different letters above columns within the same transport distance indicate significant differences in mortality rates ($P < 0.05$)

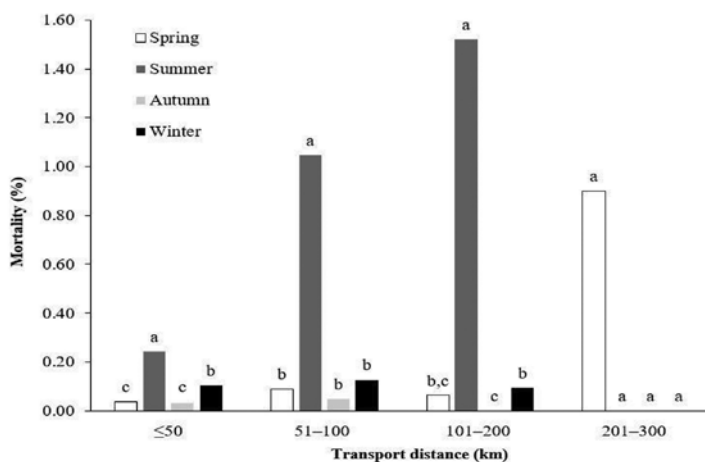


Fig. 4. Transport-related mortality rates of piglets by season and transport distance in the Czech Republic during the period 2017–2023

Different letters above columns within the same transport distance indicate significant differences in mortality rates ($P < 0.05$)

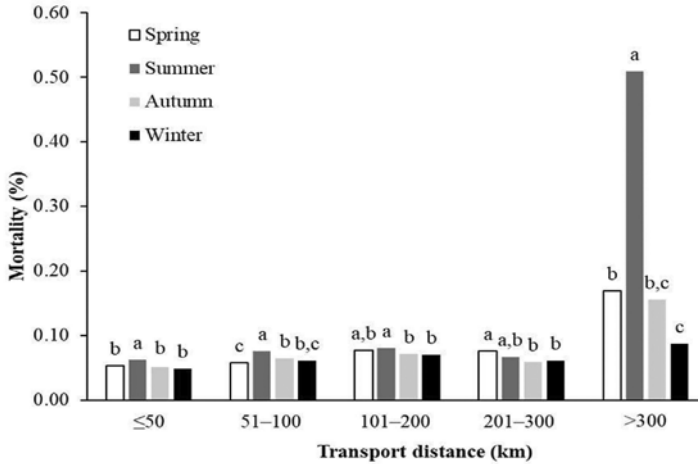


Fig. 5. Transport-related mortality rates of finishing pigs by season and transport distance in the Czech Republic during the period 2017–2023

Different letters above columns within the same transport distance indicate significant differences in mortality rates ($P < 0.05$)

Discussion

The significantly higher mortality rates observed during summer across all pig categories align with existing literature linking elevated ambient temperatures to increased transport stress and mortality risk (Warriss and Brown 1994; Večerek et al. 2006; Gade et al. 2007; Averos et al. 2008; Sutherland et al. 2009; Haley et al. 2010). Pigs are particularly sensitive to heat stress due to their limited ability to regulate body temperature—they lack functional sweat glands and rely on respiratory evaporation for thermoregulation, which becomes insufficient under conditions of high temperature and humidity (Mayorga et al. 2018; Katiyar et al. 2025). Moreover, intensive genetic selection for traits such as rapid lean tissue growth, high reproductive output, and improved feed efficiency has inadvertently further reduced heat tolerance, as these productivity gains are accompanied by increased metabolic heat production (Mayorga et al. 2018; Katiyar et al. 2025). This vulnerability is likely to become increasingly problematic in the context of climate change, with rising ambient temperatures and more frequent extreme heat events compounding the thermal challenges faced during transport.

In this study, sows and finishing pigs showed the lowest mortality during winter, suggesting that these categories may tolerate cold stress better than heat, or at least that winter conditions during transport were less extreme than summer peaks. Conversely, piglets experienced their lowest mortality in autumn, possibly due to more moderate environmental conditions and lower susceptibility to cold at that stage of development. However, given their immature thermoregulatory capacity (Gomez-Prado et al. 2022), the fact that summer was still the most lethal season indicates that heat stress can override cold-related risks, particularly when combined with extended journey times.

These findings support and extend previous research and are consistent with EFSA AHAW Panel (2022), which identifies summer as a high-risk period for pig transport. Similarly, Thodberg et al. (2022) found that even in moderate climates such as Denmark, temperatures inside trucks transporting sows to slaughter—especially during some summer

and autumn journeys—exceeded the upper limit of the sows' thermal comfort zone. Together, these lines of evidence reinforce that seasonal heat-related risks are not limited to extreme climates or to a single pig category. By expanding the scope to include sows and piglets, our study provides robust evidence that these risks extend beyond finishers and warrant broader consideration in transport regulations, vehicle design, and management practices.

Transport distance also significantly affected mortality rates, with the highest losses occurring at distances exceeding 300 km for both sows and finishing pigs. These results are consistent with earlier studies showing increased mortality with longer journeys (Voslářová et al. 2017; Dalla Costa et al. 2019; Romero et al. 2022), likely due to extended exposure to multiple stressors.

Interestingly, piglets did not follow the same linear trend. The highest mortality was observed at intermediate distances (51–200 km), while the lowest was found in very short journeys (≤ 50 km). Journeys of 201–300 km were rare, and none exceeded 300 km, limiting interpretability in that range. These patterns may reflect management decisions to avoid long-distance transport of piglets, but they also suggest that moderate distances can still be hazardous, particularly under adverse environmental conditions. The observed mortality trends underline the importance of distance-specific risk management. While longer distances are intuitively more stressful, this study shows that medium-range journeys can also be harmful, particularly for young or physiologically vulnerable animals.

Similarly, some studies have reported no clear association between transport distance and mortality of finishing pigs (Kephart et al. 2010; Marti et al. 2022), while others have even observed higher mortality rates in animals transported over shorter distances (Sutherland et al. 2009). Such divergent findings may, in part, be explained by variation in the definitions of 'long' and 'short' transport distances, as the thresholds used may differ considerably between studies, which complicates cross-study comparisons.

When long transport distances coincided with high summer temperatures, the combined effect on mortality was more pronounced than that of either factor alone. This synergistic impact was most evident in sows and finishing pigs, where mortality reached 1.34% and 0.51%, respectively. The pattern suggests that pigs are particularly vulnerable to heat stress when prolonged confinement and transport-related factors compound thermal load. These findings mirror the pattern previously reported in ducks (Justová et al. 2025a), which also exhibited increased mortality during long-distance transport under heat stress conditions. However, the critical conditions differ in other poultry: for both laying hens and broilers, winter transport over very long distances has been identified as especially high-risk (Justová et al. 2025a), pointing to a greater susceptibility to cold stress under extended travel. Similarly, in cows, winter combined with the longest transport distances resulted in the highest mortality rates (Justová et al. 2025b). Comparable synergistic effects have recently been described in rabbits, with the highest mortality observed during long-distance transport in spring, further underscoring that seasonal vulnerability varies markedly among species (Lakomá et al. 2025). These contrasting seasonal sensitivities highlight the importance of species-specific transport guidelines that address not only individual risk factors, but also their interactions.

In piglets, the most detrimental combinations also occurred during summer but were associated with medium-range transport distances (51–200 km) rather than the longest journeys. This may reflect the interplay between physiological immaturity and transport conditions insufficiently adapted to their needs—particularly for distances deemed too short to warrant specialized handling. Averós et al. (2010) likewise reported that journey duration and outside temperature can interact, with higher temperatures substantially amplifying the negative effects of long transport. However, they also noted that their findings were based on a relatively small sample size and few piglet

deaths, underscoring the need for cautious interpretation. In our case, the low incidence of journeys spanning 201–300 km and the absence of transports exceeding 300 km in this age category likewise constrained the ability to comprehensively assess all season–distance interactions.

Overall, these results provide compelling evidence that season and transport distance interact synergistically to influence mortality risk. The interaction is not simply additive; extreme values of both factors can compound stress, pushing animals beyond their physiological limits. This pattern was consistent across all pig categories, though the magnitude of the effect varied, underscoring category-specific vulnerabilities. Given the completeness and national scope of our dataset, these insights provide a robust, representative basis for evidence-based welfare policy, moving beyond findings from studies limited to specific companies or regions and offering practical guidance for risk assessment that considers both factors in combination.

Acknowledgements

This study was supported by the Internal Creative Agency of the University of Veterinary Sciences Brno (Project No. 2024ITA26).

References

- Averos X, Knowles TG, Brown SN, Warriss PD, Gosalvez LF 2008: Factors affecting the mortality of pigs being transported to slaughter. *Vet Rec* **163**: 386-390
- Council of the European Union 2005: 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. *O J EU L3*: 1-44
- Dalla Costa OA, Dalla Costa FA, Feddern V, dos Santos LL, Coldebella A, Gregory NG, de Lima GJ 2019: Risk factors associated with pig pre-slaughtering losses. *Meat Sci* **155**: 61-68
- EFSA AHAW Panel, Nielsen SS, Alvarez J, Bicout DJ, Calistri P, Canali E, Drewe JA, Garin-Bastuji B, Gonzales Rojas JL, Gortazar Schmidt C, Michel V, Miranda Chueca MA, Padalino B, Pasquali P, Roberts HC, Spoolder H, Stahl K, Velarde A, Viltrop A, Winckler C, Earley B, Edwards S, Faucitano L, Marti S, Miranda de la Lama GC, Nanni Costa L, Thomsen PT, Ashe S, Mur L, Van der Stede Y, Herskin M 2022: Scientific opinion on the welfare of pigs during transport. *EFSA J* **20**: 7445
- Fogsgaard KK, Herskin MS, Thodberg K 2018: Transportation of cull sows—A descriptive study of the clinical condition of cull sows before transportation to slaughter. *Transl Anim Sci* **2**: 280-289
- Gade PB, Christensen L, Baltzer M, Petersen JV 2007: Causes of preslaughter mortality in Danish slaughter pigs with special emphasis on transport. *Anim Welf* **16**: 459-470
- Gómez-Prado J, Pereira AMF, Wang D, Villanueva-García D, Domínguez-Oliva A, Mora-Medina P, Hernández-Avalos I, Martínez-Burnes J, Casas-Alvarado A, Olmos-Hernández A, Ramírez-Necoechea R, Verdusco-Mendoza A, Hernández A, Torres F, Mota-Rojas D 2022: Thermoregulation mechanisms and perspectives for validating thermal windows in pigs with hypothermia and hyperthermia: An overview. *Front Vet Sci* **9**: 1023294
- Goumon S, Brown JA, Faucitano L, Bergeron R, Widowski TM, Crowe T, Connor ML, Gonyou HW 2013: Effects of transport duration on maintenance behavior, heart rate and gastrointestinal tract temperature of market-weight pigs in two seasons. *J Anim Sci* **91**: 4925-4935
- Grandin T 1997: Assessment of stress during handling and transport. *J Anim Sci* **75**: 249-257
- Grandin T 2016: Transport fitness of cull sows and boars: A comparison of different guidelines of fitness for transport. *Animals* **6**: 77
- Haley C, Dewey CE, Widowski T, Friendship R 2010: Relationship between estimated finishing-pig space allowance and in-transit loss in a retrospective survey of three packing plants in Ontario in 2003. *Can Vet J* **74**: 178-184
- Haley C, Dewey CE, Widowski T, Poljak Z, Friendship R 2008: Factors associated with in-transit losses of market hogs in Ontario in 2001. *Can Vet J* **72**: 377-384
- Justová E, Večerek V, Semerád Z, Vučinić M, Válková L, Voslářová E 2025a: The synergistic effect of transport distance and season on poultry mortality during transport to slaughterhouses. *Poult Sci* **104**: 105447
- Justová E, Večerek V, Semerád Z, Kaluža M, Dimuccio MM, Voslářová E 2025b: Evaluating the synergistic impact of season and transport distance on bovine mortality during transit to slaughter. *Acta Vet Brno* **94**: 307-315
- Katiyar R, Gonmei C, Deori S, Singh M, Abedin SN, Rautela R, Singh NS, Chakravarty H, Das M, Choudhury BU, Mishra VK 2025: Effect of heat stress on pig production and its mitigation strategies: A review. *Trop Anim Health Prod* **57**: 139

- Kephart KB, Harper MT, Raines CR 2010: Observations of market pigs following transport to a packing plant. *J Anim Sci* **88**: 2199-2203
- Lakomá T, Justová E, Večerek V, Semerád Z, Kadlecová G, Nenadović K, Voslářová E 2025: Combined effects of transport distance and season on rabbit mortality during pre-slaughter transport. *Acta Vet Brno* **94**: 329-336
- Marti E, Nannoni E, Visentin G, Sardi L, Martelli G, Belperio S, Liuzzo G 2022: Mortality during transport of pigs subjected to long journeys: A study in a large European abattoir. *Vet Sci* **9**: 590
- Mayorga EJ, Renaudeau D, Ramirez BC, Ross JW, Baumgard LH 2018: Heat stress adaptations in pigs. *Anim Front* **9**: 54-61
- Nielsen BL, Dybkjær L, Herskin MS 2011: Road transport of farm animals: Effects of journey duration on animal welfare. *Animal* **5**: 415-427
- Padalino B, Tullio D, Cannone S, Bozzo G 2018: Road transport of farm animals: Mortality, morbidity, species and country of origin at a Southern Italian control post. *Animals* **8**: 155
- Rioja-Lang FC, Brown JA, Brockhoff EJ, Faucitano L 2019: A review of swine transportation research on priority welfare issues: A Canadian perspective. *Front Vet Sci* **6**: 36
- Romero MH, Sanchez JA, Hernandez RO 2022: Field trial of factors associated with the presence of dead and non-ambulatory pigs during transport across three Colombian slaughterhouses. *Front Vet Sci* **9**: 790570
- Schwartzkopf-Genswein KS, Faucitano L, Dadgar S, Shand P, Gonzalez LA, Crowe TG 2012: Road transport of cattle, swine and poultry in North America and its impact on animal welfare, carcass and meat quality: A review. *Meat Sci* **92**: 227-243
- Sutherland MA, McDonald A, McGlone JJ 2009: Effects of variations in the environment, length of journey and type of trailer on the mortality and morbidity of pigs being transported to slaughter. *Vet Rec* **165**: 13-18
- Thodberg K, Foldager L, Fogsgaard KK, Gaillard C, Herskin MS 2022: Temperature conditions during commercial transportation of cull sows to slaughter. *Comput Electron Agric* **192**: 106626
- Válková L, Večerek V, Voslářová E, Kaluža M, Takáčová D, Brscic M 2022: Animal welfare during transport: Comparison of mortality during transport from farm to slaughter of different animal species and categories in the Czech Republic. *Ital J Anim Sci* **21**: 914-923
- Večerek V, Malena M, Malena M Jr, Voslářová E, Chloupek P 2006: The impact of the transport distance and season on losses of fattened pigs during transport to the slaughterhouse in the Czech Republic from 1997 to 2004. *Vet Med* **51**: 21-28
- Voslářová E, Večerek V, Passantino A, Chloupek P, Bedáňová I 2017: Transport losses in finisher pigs: Impact of transport distance and season of the year. *Asian-Australas J Anim Sci* **30**: 119-124
- Warriss PD 1998: The welfare of slaughter pigs during transport. *Anim Welf* **7**: 365-381
- Warriss PD, Brown SN 1994: A survey of mortality in slaughter pigs during transport and lairage. *Vet Rec* **134**: 513-515
- Zurbrigg K, Bertolini F, Walugembe M, van Dreumel T, Alves D, Friendship R, O'Sullivan TL, Rothschild MF 2021: A genome-wide analysis of cardiac lesions of pigs that die during transport: Is heart failure of in-transit-loss pigs associated with a heritable cardiomyopathy? *Can J Vet Res* **85**: 119-126
- Zurbrigg K, van Dreumel T, Rothschild MF, Alves D, Friendship R, O'Sullivan TL 2017: Rapid communication: Postmortem lesions and heart weights of in-transit-loss market pigs in Ontario. *J Anim Sci* **95**: 5532-5536