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Supplementary material

Prevalence, risk factors, and main characteristics of bruises in cattle: A meta-analysis in the American continent

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Supplementary material

Information

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Table S1. Search methods: detailed search strategy

Database	Outcome	Search command	Records
PubMed	Prevalence	(((((bovine[Title/Abstract] OR cattle[Title/Abstract])) AND (((bruising[Title/Abstract] OR bruises[Title/Abstract] OR bruised[Title/Abstract])))) AND ((prevalence[Title/Abstract] OR incidence[Title/Abstract] OR occurrence[Title/Abstract] OR frequency[Title/Abstract])))	41
	Characteristics of bruises	(((((bovine[Title/Abstract] OR cattle[Title/Abstract])) AND (((bruising[Title/Abstract] OR bruises[Title/Abstract] OR bruised[Title/Abstract])))) AND (((((((characteristics[Title/Abstract] OR traits[Title/Abstract] OR severity[Title/Abstract] OR color[Title/Abstract] OR removed meat[Title/Abstract] OR score[Title/Abstract] OR size[Title/Abstract]))	34
	Risk factors	(((((bovine[Title/Abstract] OR cattle[Title/Abstract])) AND (((bruising[Title/Abstract] OR bruises[Title/Abstract] OR bruised[Title/Abstract])))) AND (((((((risk factor[Title/Abstract] OR horns[Title/Abstract] OR sex[Title/Abstract] OR fat cover[Title/Abstract] OR handling[Title/Abstract] OR transport[Title/Abstract] OR time[Title/Abstract] OR stocking density[Title/Abstract]))	46
Scopus	Prevalence	(TITLE-ABS-KEY (bruise* AND bruising) AND TITLE-ABS-KEY (bovine OR cattle OR cow OR bull) AND TITLE-ABS-KEY (prevalence OR incidence OR occurrence OR frequency)) AND DOCTYPE (ar)	33
	Characteristics of bruises	(TITLE-ABS-KEY (bovine OR cattle) AND TITLE-ABS-KEY (bruise* OR bruising) AND TITLE-ABS-KEY (characteristics OR traits OR severity OR color OR removed AND meat OR score OR size))	35
	Risk factors	(TITLE-ABS-KEY (bovine OR cattle) AND TITLE-ABS-KEY (bruise* OR bruising) AND TITLE-ABS-KEY ("risk factor" OR horns OR handling OR transport OR time OR "stocking density"))	116
ScienceDirect	Prevalence	(bovine OR cattle) AND (bruises OR bruised OR bruising) AND (prevalence OR incidence OR occurrence OR frequency)	14
	Characteristics of bruises	(bovine OR cattle) AND (bruises OR bruising) AND (characteristics OR color OR severity)	8
	Risk factors	(bovine OR cattle) AND (bruises OR bruising) AND ("risk factor" OR handling OR horns OR transport OR "stocking density")	21
Virtual Health Library	Prevalence	(tw:(bovine OR cattle OR cow OR bull)) AND (tw:(bruise* AND bruising)) AND (tw:(prevalence OR incidence OR occurrence OR frequency))	19
	Characteristics of bruises	tw:(bovine OR cattle)) AND (tw:(bruise* OR bruising)) AND (tw:(characteristics OR severity OR size OR removed meat OR traits OR color OR score))	65
	Risk factors	(tw:(bovine OR cattle)) AND (tw:(bruise* OR bruising)) AND (tw:(risk factor OR horns OR handling OR "stocking density" OR transport))	18
Redalyc	Prevalence	bovine OR cattle AND bruises OR bruised OR bruising AND prevalence OR incidence OR occurrence OR frequency	8
	Characteristics of bruises	(bovine OR cattle) AND (bruises OR bruising) AND (characteristics OR color OR severity)	12
	Risk factors	(bovine OR cattle) AND (bruises OR bruising) AND (risk factor OR handling OR horns OR transport OR stocking density)	16
Web of Science	Prevalence	SUBJECT: (bruise* OR bruising) AND SUBJECT: (cattle OR bovine OR cow OR bull) AND SUBJECT: (prevalence OR incidence OR occurrence OR frequency)	63
	Characteristics of bruises	SUBJECT: (bovine OR cattle) AND SUBJECT: (bruises OR bruising) AND SUBJECT: (characteristics OR traits OR size OR severity OR score OR color OR "removed meat")	72
	Risk factors	SUBJECT: (bovine OR cattle) AND SUBJECT: (bruises OR bruising) AND SUBJECT: (risk factor OR horns OR sex OR fat cover OR handling OR lairage OR transport OR time OR stocking density)	99
CAB Abstract	Prevalence	(bruise* OR Bruising) AND (cattle OR bovine) AND (prevalence OR incidence OR occurrence OR frequency)	17
	Characteristics of bruises	(bruise* OR bruising) AND (bovine OR cattle) AND (characteristics OR traits OR size OR severity OR score OR color OR "removed meat")	12
	Risk factors	(bruise* OR bruising) AND (bovine OR cattle) AND ("risk factor" OR handling OR horns OR transport OR "stocking density")	8

Supplementary material

Table S2. Excluded trials and the primary reasons for exclusion

ID	Study	The primary reason for exclusion
1	Alam, M., et al., Veterinary Record, 2010. 167(11): p. 415-419.	Study conducted out of the Americas
2	Alende, M., Revista Argentina de Producción Animal, 2010. 30(1): p. 117-129.	Not a primary study
3	Andrade, E.N., et al., Archivos de Zootecnia, 2009. 58(222): p. 301-304.	Re-use data from another study
4	Blackshaw, J., et al., Aus J of Experimental Agriculture, 1987. 27(6): p. 753-757.	Study conducted out of the Americas
5	Boleman, S.L., et al., J Anim Sci, 1998. 76(1): p. 96-103.	Does not include risk factors
6	Carvalho, M.T.d.M., et al., Veterinária e Zootecnia, 2017. 24(Suppl. 1): p. 95-104.	Not a primary study
7	Costa, L.N., et al., Veterinary Research Communications, 2006. 30: p. 379-381.	Study conducted out of the Americas
8	Cruz-Monterrosa, R.G., et al., Trop Anim Health Prod, 2017. 49(1): p. 145-152.	Does not include the protocolized outcomes
9	da Silva, J.L., et al., Archives of Veterinary Science, 2016. 21(3): p. 68-76.	Re-use data from another study
10	Eldridge, G., et al., Aus J of Experimental Agriculture, 1988. 28(6): p. 695-698.	Study conducted out of the Americas
11	Fordyce, G., et al., Aus J of Experimental Agriculture, 1988. 28(6): p. 689-693.	Study conducted out of the Americas
12	Francisco, C.L., et al., J Anim Sci, 2015. 93(11): p. 5419-29.	Lacks numerical values in an appropriate format
13	Frimpong, S., et al., Veterinary Sciences, 2014. 1(3): p. 174-191.	Study conducted out of the Americas
14	Gallo, C., et al., Archivos de Medicina Veterinaria, 2005. 37(2): p. 155-159.	Does not include risk factors
15	Grigor, P.N., et al., Livestock Production Science, 2004. 91(3): p. 219-228.	Does not include the protocolized outcomes
16	Hartman, E., et al., Safety Science, 2004. 42(9): p. 807-823.	Does not include the defined population
17	Hoffman, L.C. et al., Meat Sci, 2012. 92(2): p. 115-24.	Study conducted out of the Americas
18	Huertas, S.M., et al., Vet Med Sci, 2015. 1(1): p. 9-15.	Re-use data from another study
19	Jaja, I.F., et al., Acta Tropica, 2018. 178: p. 303-310.	Study conducted out of the Americas
20	Jarvis, A., et al., Livestock Production Science, 1995. 43(3): p. 215-224.	Study conducted out of the Americas
21	Lensink, B.J., et al., Journal of Animal Science, 2001. 79(3): p. 642-652.	Study conducted out of the Americas
22	Liotta, L., et al., Italian Journal of Animal Science, 2007. 6(4): p. 375-384.	Study conducted out of the Americas
23	Marshall, B.L., et al., New Zealand Veterinary Journal, 1977. 25(4): p. 83-86.	Does not meet the defined study characteristics
24	McCausland, I., et al., Australian veterinary journal, 1982. 58(6): p. 253-255.	Study conducted out of the Americas
25	McNally, P.W. and P.D. Warriss, Veterinary Record, 1997. 140(9): p. 231-232.	Study conducted out of the Americas
26	Meischke, H.R., et al., Australian veterinary journal, 1974. 50(10): p. 432-4.	Does not meet the defined study characteristics
27	Minka, N.S. et al., Livestock Science, 2007. 107(1): p. 91-95.	Study conducted out of the Americas
28	Moreira, P.S.A., et al., Rev Bras de Saude e Producao Animal, 2014. 15(3): p. 689-695.	Lacks numerical values in an appropriate format
29	Mpakama, T., et al., Asian-Australasian j of animal sciences, 2014. 27(5): p. 717-25.	Study conducted out of the Americas
30	Ramsay, W.R., et al., Australian veterinary journal, 1976. 52(6): p. 285-6.	Does not meet the defined study characteristics
31	Romero, M.H., et al., Rev. colomb. cienc. pecu, 2012. 25(2): p. 267-275.	Re-use data from another study
32	Strappini, A.C., et al., Livestock Science, 2012. 145(1-3): p. 271-274.	Does not include the protocolized outcomes
33	Strappini, A.C., et al., Animal, 2009. 3(5): p. 728-36.	Duplicated study
34	Tarrant, P., et al., Meat Science, 1988. 24(3): p. 209-222.	Study conducted out of the Americas

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ID	Study	The primary reason for exclusion
35	Tarrant, P., et al., Livestock Production Science, 1992. 30(3): p. 223-238.	Study conducted out of the Americas
36	Tarumán, J.A., et al., Open Access Libr. J, 2018. 5.	Does not include the defined population
37	Vimiso, P., et al., South African Journal of Animal Science, 2013. 43(1): p. 105-111.	Study conducted out of the Americas
38	von Holleben, K., et al., Deutsche Tierärztliche Wochenschrift, 2003. 110(3): p. 93-99.	Study conducted out of the Americas
39	Weeks, C.A., et al., The Veterinary record, 2002. 150(24): p. 743-8.	Study conducted out of the Americas
40	Wythes, J.R., et al., Australian Journal of Agricultural Research, 1988. 39(1): p. 97-107.	Study conducted out of the Americas
41	Wythes, J., et al., Aus J of Experimental Agriculture, 1985. 25(4): p. 727-733.	Study conducted out of the Americas
42	Wythes, J. Et al., Aus J of Experimental Agriculture, 1991. 31(2): p. 145-152.	Study conducted out of the Americas
43	Wythes, J.R., et al., Aus J of Agricultural Research, 1988. 39(1): p. 97-107.	Duplicated study
44	Wythes, J.R., et al., Aus J of Agricultural Research, 1989. 40(5): p. 1099-1109.	Study conducted out of the Americas
45	Wythes, J.R., et al., Aus J of Agricultural Research, 1988. 39(1): p. 87-95.	Study conducted out of the Americas
46	Youngers, M., et al., Kansas Agricultural Exp Station Research, 2017. 3(1): p. 12.	Re-use data from another study

Supplementary material

Table S3. List of the studies included in the meta-analysis and systematic review and assessment of risk of bias for the individual studies

1. Bertoloni W, da Silva JL, de Abreu JS, Andreolla DL. Welfare and bruise index of cattle transported in different distance and trucks design in the Mato Grosso state - Brazil. *Revista Brasileira de Saude e Producao Animal*. 2012;13(3):850-859. doi:
2. Bethancourt-Garcia JA, Vaz RZ, Vaz FN, Silva WB, Pascoal LL, Mendonça FS, et al. Pre-slaughter factors affecting the incidence of severe bruising in cattle carcasses. *Livestock Science*. 2019;222:41-48. doi:
3. Braga JS, Machado MF, Borges TD, de Souza M, Souza APO, Molento CFM. Cattle welfare assessment in two state regulated abattoirs in southern Brazil. *Archives of Veterinary Science*. 2014;19(3):24-35. doi:
4. Cardoso MRP, Moura MS, Moreira MD. Occurrence of bruises in slaughtered cattle carcasses in a slaughter plant in Uberlândia-MG. *PUBVET*. 2011;5(6):unpaginated. doi:
5. Crosi G, Prado M, Huertas S, Imelio J, Piaggio J, Gil A. Estudio observacional sobre presencia y caracterización de hematomas en carcasas vacunas de Uruguay. *Salud y Tecnología Veterinaria*. 2015;3(2):41-50. doi:
6. da Silva B, de Mattoso MRB, de Oliveiraa HC, Morais HR, de Fátima K, Biase NG. Quantity, location, and description of bruises in beef cattle slaughtered under sanitary inspection. *Acta Scientiae Veterinariae*. 2014;42(1). doi:
7. de Andrade EN, de Oliveira RR, Silva RAMS, Gonçalves HC, Pinheiro RSB. Prevalence of carcass bruising in cattle meat slaughtered in Pantanal, Mato Grosso do Sul state, after fluvial transport. *Ciencia e Tecnologia de Alimentos*. 2008;28(4):822-829. doi:
8. de Andrade EN, Silva RAMS, Roça RDO, Da Silva LAC, Gonçalves HC, Pinheiro RSB. Occurrence of carcass bruising of beef cattle in the Pantanal related to time spent transport. *Ciencia Rural*. 2008;38(7):1991-1996. doi:
9. de Assis DR, Rezende-Lago NC, de Marchi PG, DAmato CC. Perdas diretas ocasionadas por abscessos e hematomas em carcaças de bovinos Direct losses due abscesses and bruised in beef carcasses. *Revista Portuguesa de Ciências Veterinárias*. 2011;106(577-580):47-51. doi:
10. de Freslon I, Strappini AC, Soto-Gamboa M, Gallo C. Caracterización de la reactividad conductual frente al manejo y su relación con el cortisol sanguíneo, contusiones y pH de la carne en novillos. *Archivos de Medicina Veterinaria*. 2014;46(2):229-237. doi:
11. Eastwood LC, Boykin CA, Harris MK, Arnold AN, Hale DS, Kerth CR, et al. National Beef Quality Audit-2016: Transportation, mobility, and harvest-floor assessments of targeted characteristics that affect quality and value of cattle, carcasses, and by-products. *Translational Animal Science*. 2017;1(2):229-238. doi:
12. Gallo C, Caro M, Villarroel C, Araya P. Characteristics of cattle slaughtered within the Xth Region (Chile) according to the terms stated by the official chilean standards for classification and carcass grading. *Archivos de Medicina Veterinaria*. 1999;31(1):81-88. doi:
13. Gallo C, Espinoza MA, Gasic J. Effects of 36 hours road transport with or without a resting period on live weight and some meat quality aspects in cattle. *Archivos de Medicina Veterinaria*. 2001;33(1):43-53. doi:
14. Gallo C, Perez VS, Sanhueza VC, Gasic YJ. Effects of transport time of steers before slaughter on behaviour, weight loss and some carcass characteristics. *Archivos de Medicina Veterinaria*. 2000;32(2):157-170. doi:
15. Garcia LG, Nicholson KL, Hoffman TW, Lawrence TE, Hale DS, Griffin DB, et al. National Beef Quality Audit 2005: Survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers. *Journal of Animal Science*. 2008;86(12):3533-3543. doi:
16. Godoy M, Fernández H, Morales MA, Ibarra L, Sepúlveda C. Bruises in bovine carcasses. Incidence and potential risk. *Avances en Ciencias Veterinarias*. 1986;1(1):22-25. doi:
17. Goldhawk C, Janzen E, Gonzalez LA, Crowe T, Kastelic J, Kehler C, et al. Trailer temperature and humidity during winter transport of cattle in Canada and evaluation of indicators used to assess the welfare of cull beef cows before and after transport. *Journal of Animal Science*. 2015;93(7):3639-3653. doi:
18. Harris MK, Eastwood LC, Boykin CA, Arnold AN, Gehring KB, Hale DS, et al. National Beef Quality Audit-2016: Transportation, mobility, live cattle, and carcass assessments of targeted producer-related characteristics that affect value of market cows and bulls, their carcasses, and associated by-products. *Translational Animal Science*. 2017;1(4):570-584. doi:
19. Huertas SM, Gil AD, Piaggio JM, van Eerdenburg FJCM. Transportation of beef cattle to slaughterhouses and how this relates to animal welfare and carcase bruising in an extensive production system. *Animal Welfare*. 2010;19(3):281-285. doi:

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20. Huertas SM, Kempener R, van Eerdenburg FJCM. Relationship between Methods of Loading and Unloading, Carcass Bruising, and Animal Welfare in the Transportation of Extensively Reared Beef Cattle. *Animals*. 2018;8(7). doi:
21. Lee TL, Reinhardt CD, Bartle SJ, Vahl CI, Siemens M, Thomson DU. Assessment of risk factors contributing to carcass bruising in fed cattle at commercial slaughter facilities. *Translational Animal Science*. 2017;1(4):489-497. doi:
22. Lorenzen CL, Hale DS, Griffin DB, Savell JW, Belk KE, Frederick TL, et al. National Beef Quality Audit: survey of producer-related defects and carcass quality and quantity attributes. *Journal of Animal Science*. 1993;71(6):1495-1502. doi:
23. McKeith RO, Gray GD, Hale DS, Kerth CR, Griffin DB, Savell JW, et al. National Beef Quality Audit-2011: Harvest-floor assessments of targeted characteristics that affect quality and value of cattle, carcasses, and byproducts. *Journal of Animal Science*. 2012;90(13):5135-5142. doi:
24. McKenna DR, Roebert DL, Bates PK, Schmidt TB, Hale DS, Griffin DB, et al. National Beef Quality Audit-2000: survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers. *Journal of Animal Science*. 2002;80(5):1212-1222. doi:
25. Mendonça FS, Vaz RZ, Cardoso FF, Restle J, Vaz FN, Pascoal LL, et al. Pre-slaughtering factors related to bruises on cattle carcasses. *Animal Production Science*. 2018;58(2):385-392. doi:
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27. Mendonça FS, Vaz RZ, Vaz FN, Leal WS, Silveira IDB, Restle J, et al. Causes of bruising in carcasses of beef cattle during farm, transport, and slaughterhouse handling in Brazil. *Animal Science Journal*. 2019;90(2):288-296. doi:
28. Menezes LDM. Analysis of intrinsic and transportation variables about bruises profile in cattle carcasses. *Revista Electronica de Veterinaria*. 2018;19(8). doi:
29. Miranda-de la Lama GC, Leyva IG, Barreras-Serrano A, Perez-Linares C, Sanchez-Lopez E, Maria GA, et al. Assessment of cattle welfare at a commercial slaughter plant in the northwest of Mexico. *Trop Anim Health Prod*. 2012;44(3):497-504. doi:
30. Moreira PSA, Polizel Neto A, Martins LR, Lourenço FJ, Palhari C, Faria FF. Occurrence of carcasses bruises of beef cattle transported by two distances. *Revista Brasileira de Saude e Producao Animal*. 2014;15(3):689-695. doi:
31. Petroni R, Bürger KP, González PO, Rossi GAM, Vidal-Martins AMC, Aguilar CEG. Bruises occurrence in cattle carcasses at a slaughterhouse. *Revista Brasileira de Saude e Producao Animal*. 2013;14(3):478-484. doi:
32. Rebagliati JE, Ballerio M, Acerbi R, Diaz M, Alvarez MM, Bigatti F, et al. Evaluación de las prácticas ganaderas en bovinos que causan perjuicios económicos en plantas frigoríficas de la República Argentina (2005). *REDVET Revista Electrónica de Veterinaria*. 2008;IX(10B):1-40. doi:
33. Rezac DJ, Thomson DU, Siemens MG, Prouty FL, Reinhardt CD, Bartle SJ. A survey of gross pathologic conditions in cull cows at slaughter in the Great Lakes region of the United States. *Journal of dairy science*. 2014;97(7):4227-4235. doi:
34. Roeber DL, Mies PD, Smith CD, Belk KE, Field TG, Tatum JD, et al. National market cow and bull beef quality audit-1999: a survey of producer-related defects in market cows and bulls. *Journal of Animal Science*. 2001;79(3):658-665. doi:
35. Romero MH, Gutierrez C, Sanchez JA. Evaluation of preslaughter management and its relationship with the bruises presence on beef carcasses. *Biosalud*. 2011;10(2):28-36. doi:
36. Romero MH, Uribe-Velasquez LF, Sanchez JA, Miranda-de la Lama GC. Risk factors influencing bruising and high muscle pH in Colombian cattle carcasses due to transport and pre-slaughter operations. *Meat Science*. 2013;95(2):256-263. doi:
37. Sanchez-Perez JN, Robles-Estrada JC, Portillo-Loera JJ, Rios-Rincón FG, Felix-Bernal JA, Leyva-Medina KH, et al. Prevalence, characterization and risk factors associated with bovine carcasses bruises at a slaughterhouse in Sinaloa, Mexico. *Biotechnia*. 2019;XXI(3):114-120. doi:
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39. Strappini AC, Frankena K, Metz JH, Gallo C, Kemp B. Prevalence and risk factors for bruises in Chilean bovine carcasses. *Meat Science*. 2010;86(3):859-864. doi:
40. Strappini AC, Frankena K, Metz JH, Gallo C, Kemp B. Characteristics of bruises in carcasses of cows sourced from farms or from livestock markets. *Animal*. 2012;6(3):502-509. doi:

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41. Strappini AC, Metz JH, Gallo C, Frankena K, Vargas R, de Freslon I, et al. Bruises in culled cows: when, where and how are they inflicted? *Animal*. 2013;7(3):485-491. doi:
42. Tuninetti N, Blainq L, Otero JL. Evaluación de las contusiones y del pH en canales bovinas en un matadero de la provincia de Santa Fé. *InVet*. 2017;19(1). doi:
43. Van Donkersgoed J, Jewison G, Bygrove S, Gillis K, Malchow D, McLeod G. Canadian beef quality audit 1998-99. *Canadian Veterinary Journal*. 2001;42(2):121-126. doi:
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45. Vega-Britez GD, Alcaraz A, Lesmo ND, Alvarenga JD, Velazquez JA. Effect of land transport on bovine carcass in the Northern of Paraguay. *Compendio de Ciencias Veterinarias*. 2019;9(1):35-41. doi:
46. Youngers ME, Thomson DU, Schwandt EF, Simroth JC, Bartle SJ, Siemens MG, et al. Case study: Prevalence of horns and bruising in feedlot cattle at slaughter. *Professional Animal Scientist*. 2017;33(1):135-139. doi:

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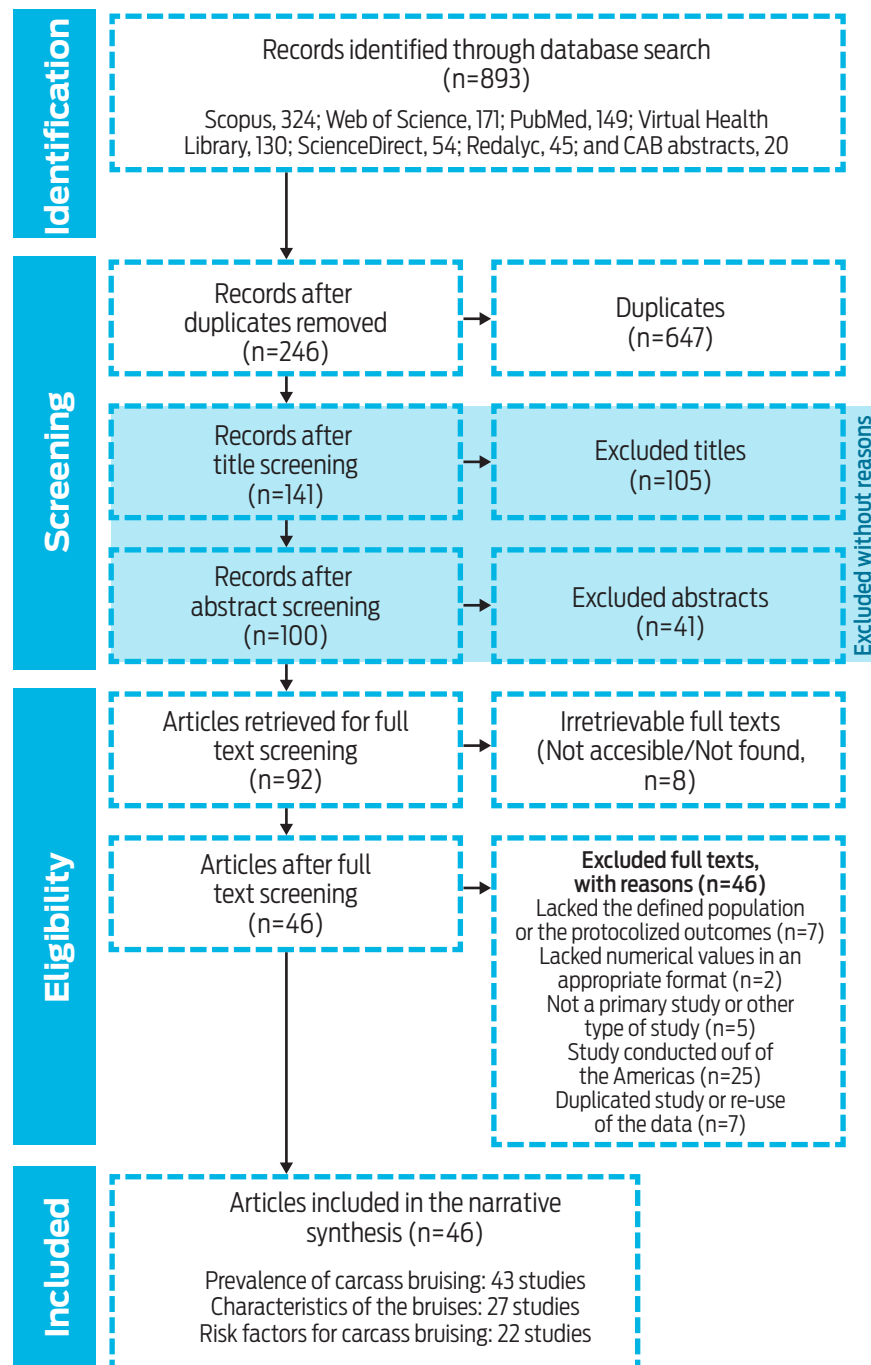


Figure S1. PRISMA flow chart for the selection of the studies included in the meta-analysis and systematic review.

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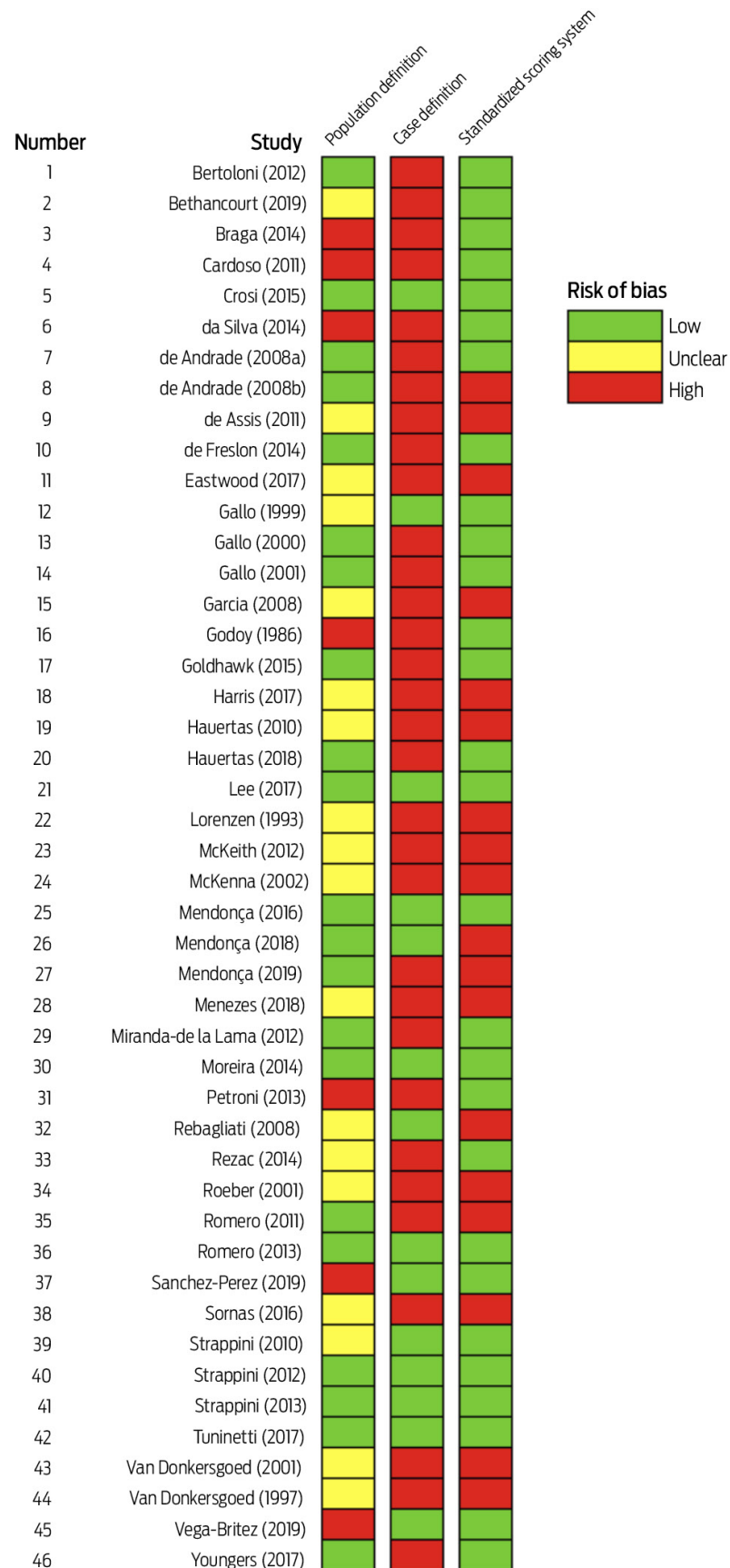


Figure S2. Assessment of risk of bias for the individual studies

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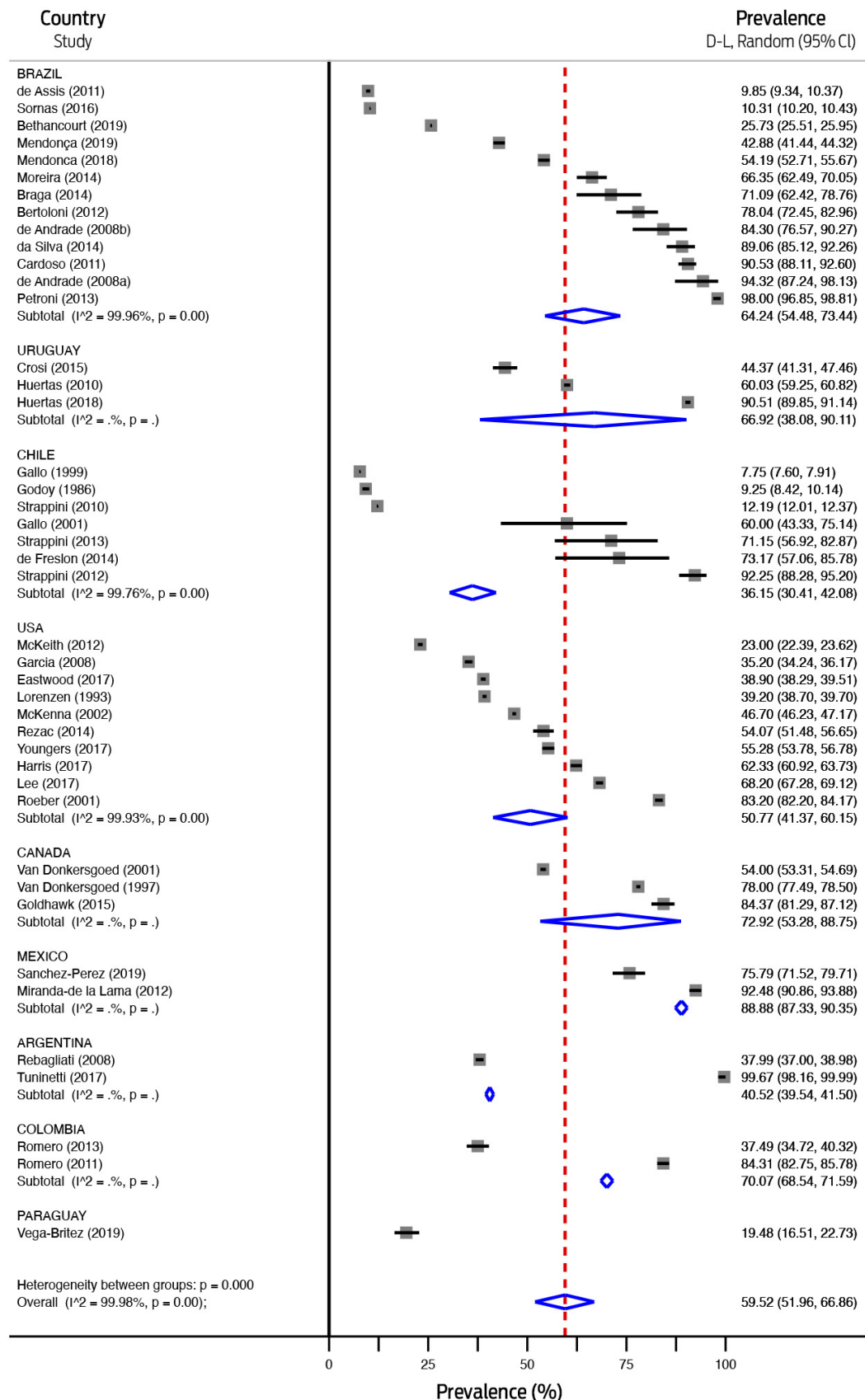


Figure S3. Forest plot of the prevalence of carcass bruising by country

Supplementary material

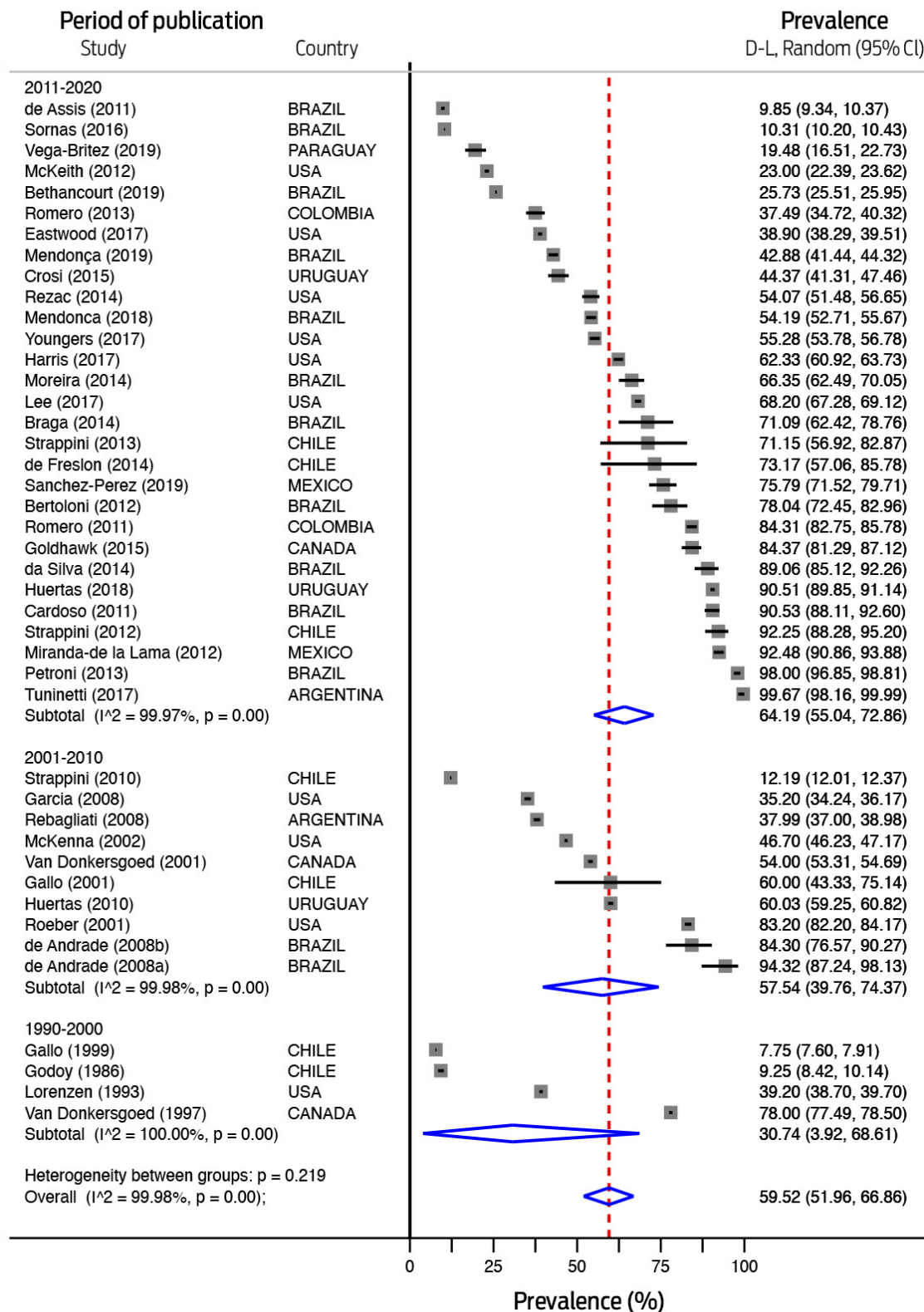


Figure S4. Forest plot of the prevalence of carcass bruising segmented by decades

Supplementary material

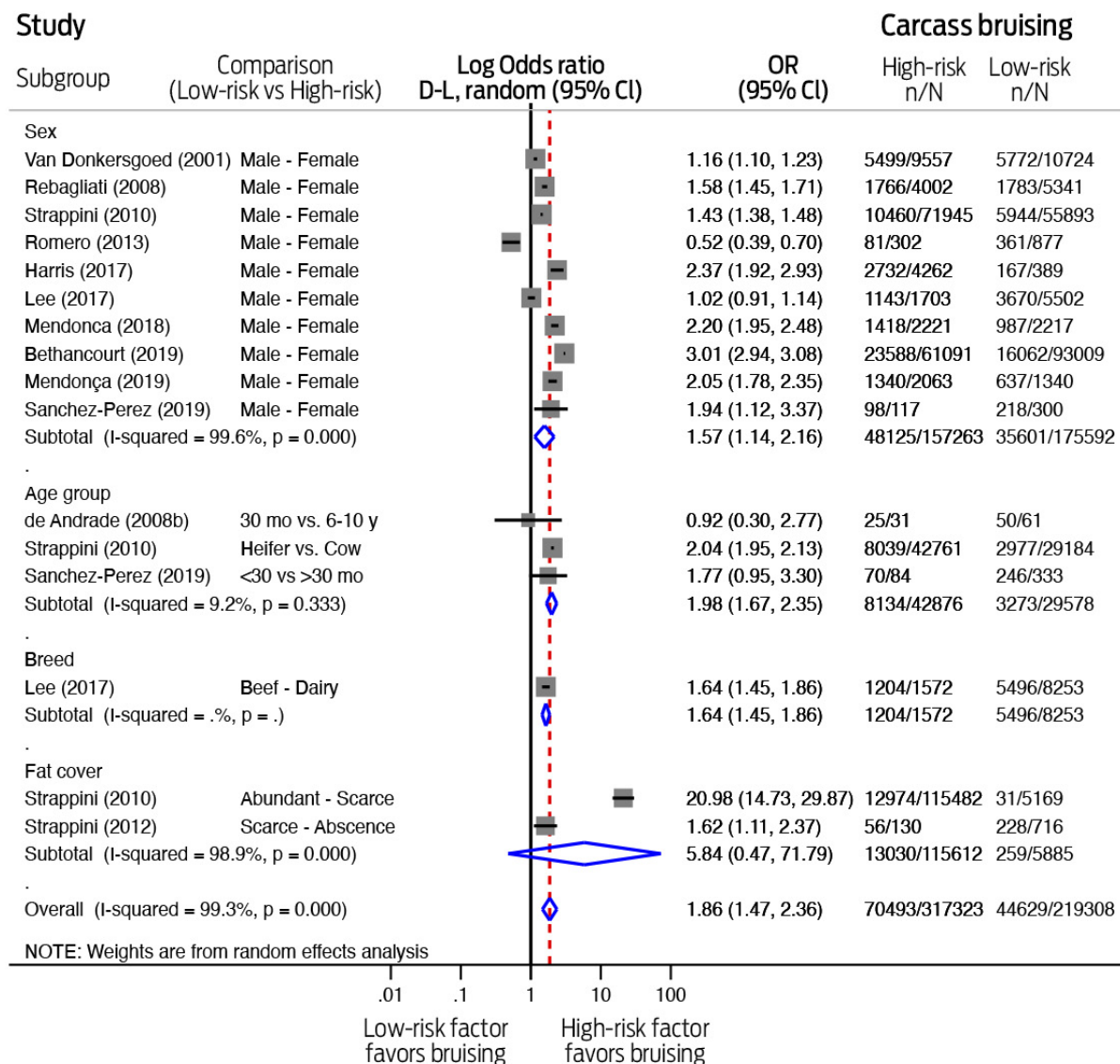


Figure S5. Forest plot of the OR of carcass bruising for intrinsic risk factors

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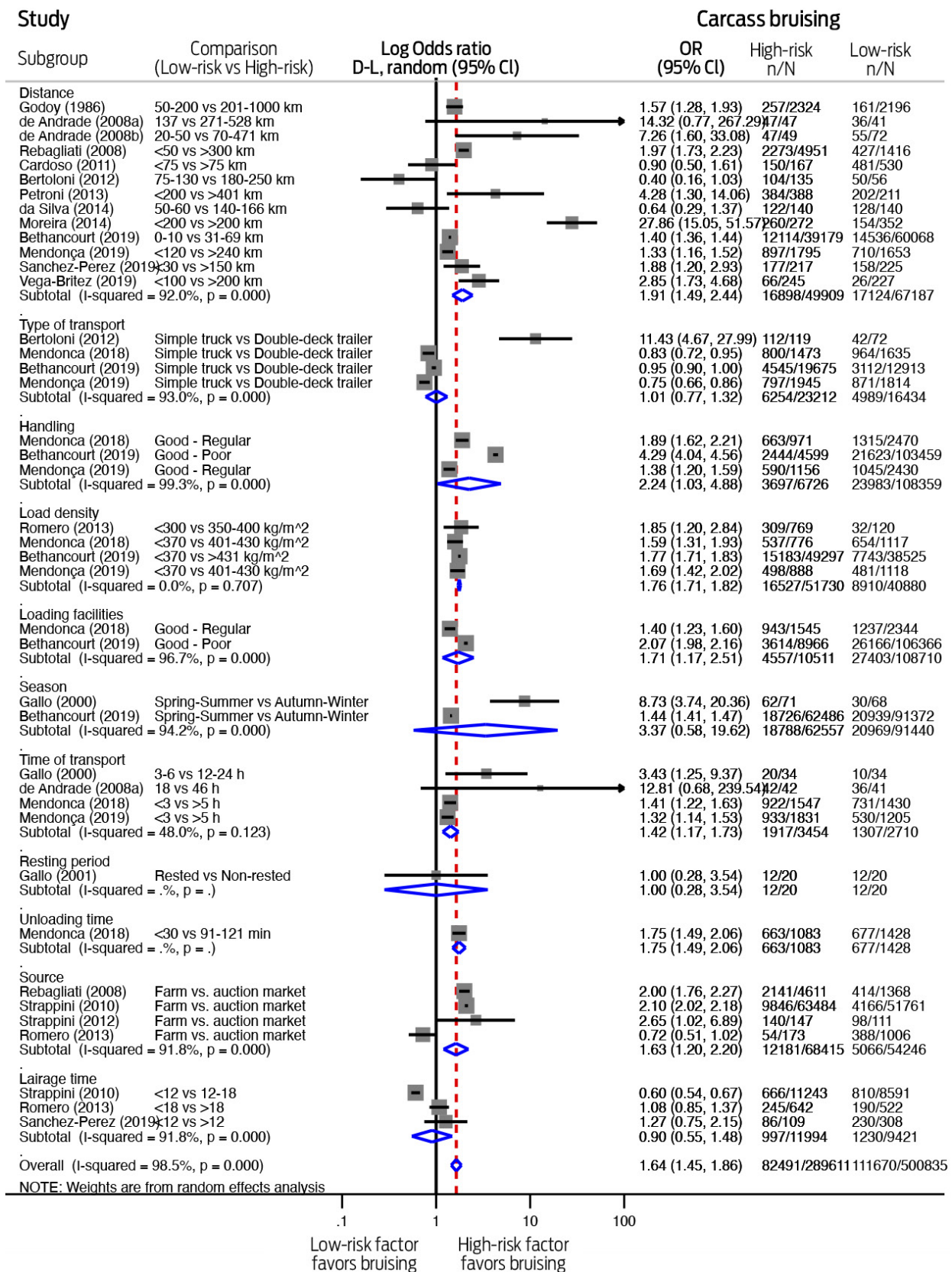


Figure S6. Forest plot of the OR of carcass bruising for extrinsic risk factors