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Transport of broilers

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Presentation based on the following recent publications

- Cockram, M.S. and Dulal, K.J., 2018. Injury and mortality in broilers during handling and transport to slaughter. *Canadian Journal of Animal Science* 98: 416–432. https://doi.org/10.1139/cjas-2017-0076
- Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208.
- Cockram, M.S., Dulal, K.J., Mohamed, R.A. and Revie, C.W. Risk factors for bruising and mortality of broilers during manual handling, module loading, transport and lairage. *Canadian Journal of Animal Science* https://doi.org/10.1139/CJAS-2018-0032

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Research funded by

Canadian Poultry Research Council

The Sir James Dunn Animal Welfare Centre

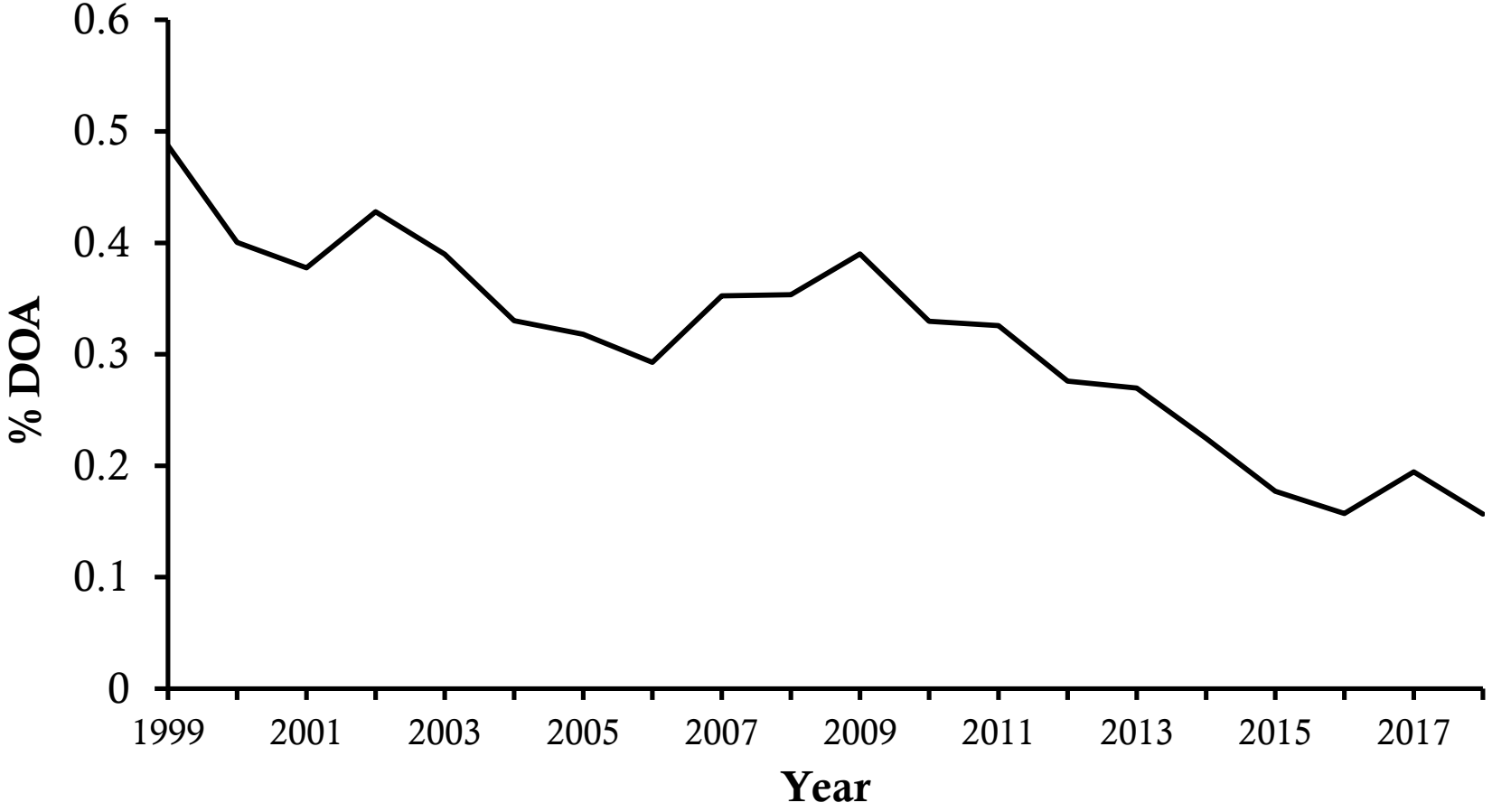
The following are thanked for their assistance and cooperation

Broiler processing plants in Atlantic Canada

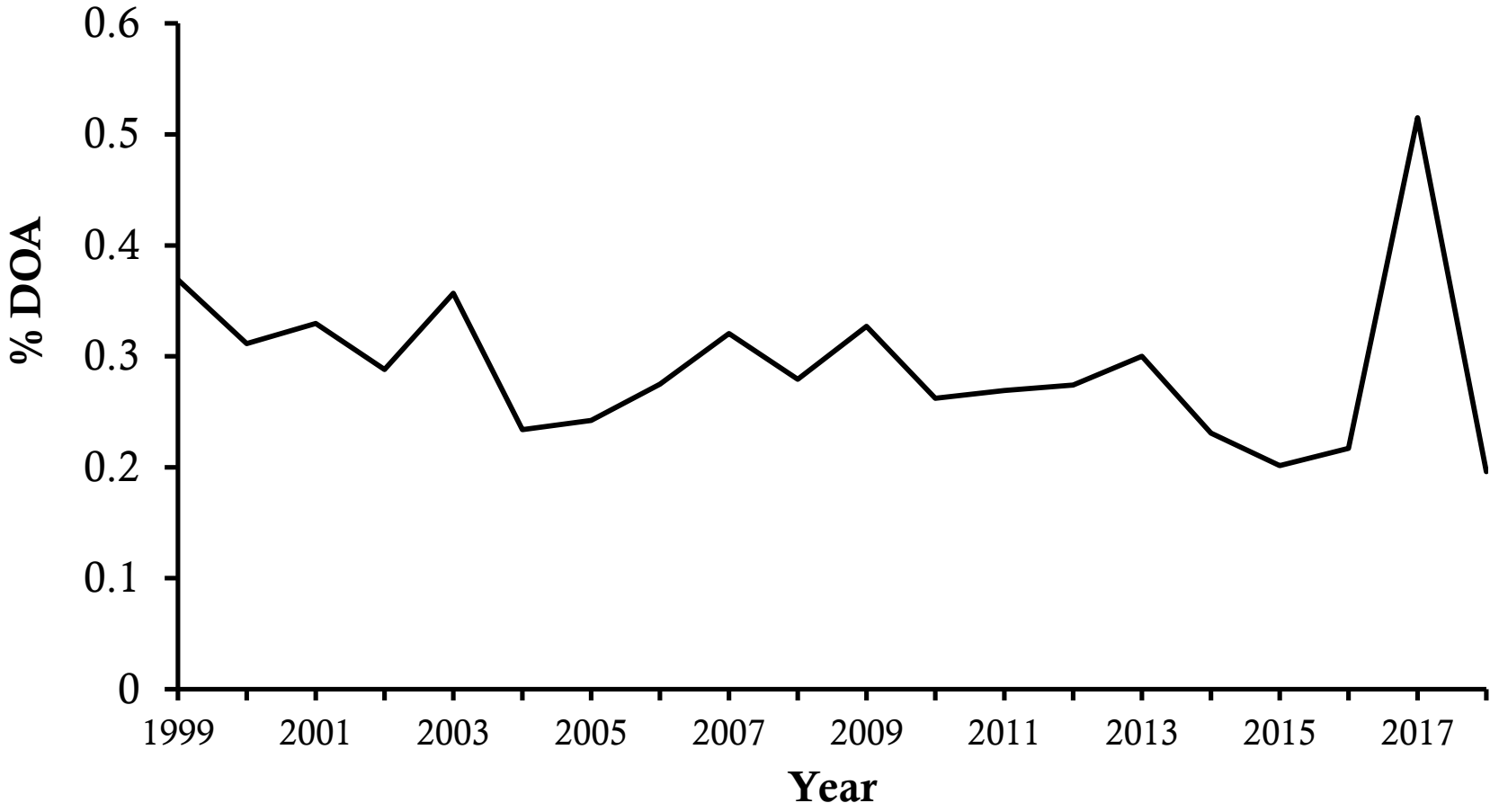
Broiler producers on Prince Edward Island and in Nova Scotia

Factors affecting injury and mortality in broilers during handling and transport to slaughter

- Multiple factors affect the risk of injury and mortality at each stage.
- Many of these factors interact with each other in an additive manner
- There are carry-over effects from one stage to the next.



Percentage of poultry slaughtered at federally inspected slaughter plants in Canada that were condemned due to dead-on-arrival (DOA) (Agriculture and Agri-Food Canada 2018).



Percentage of poultry slaughtered at federally inspected slaughter plants in Atlantic Canada that were condemned due to dead-on-arrival (DOA) (Agriculture and Agri-Food Canada 2018).

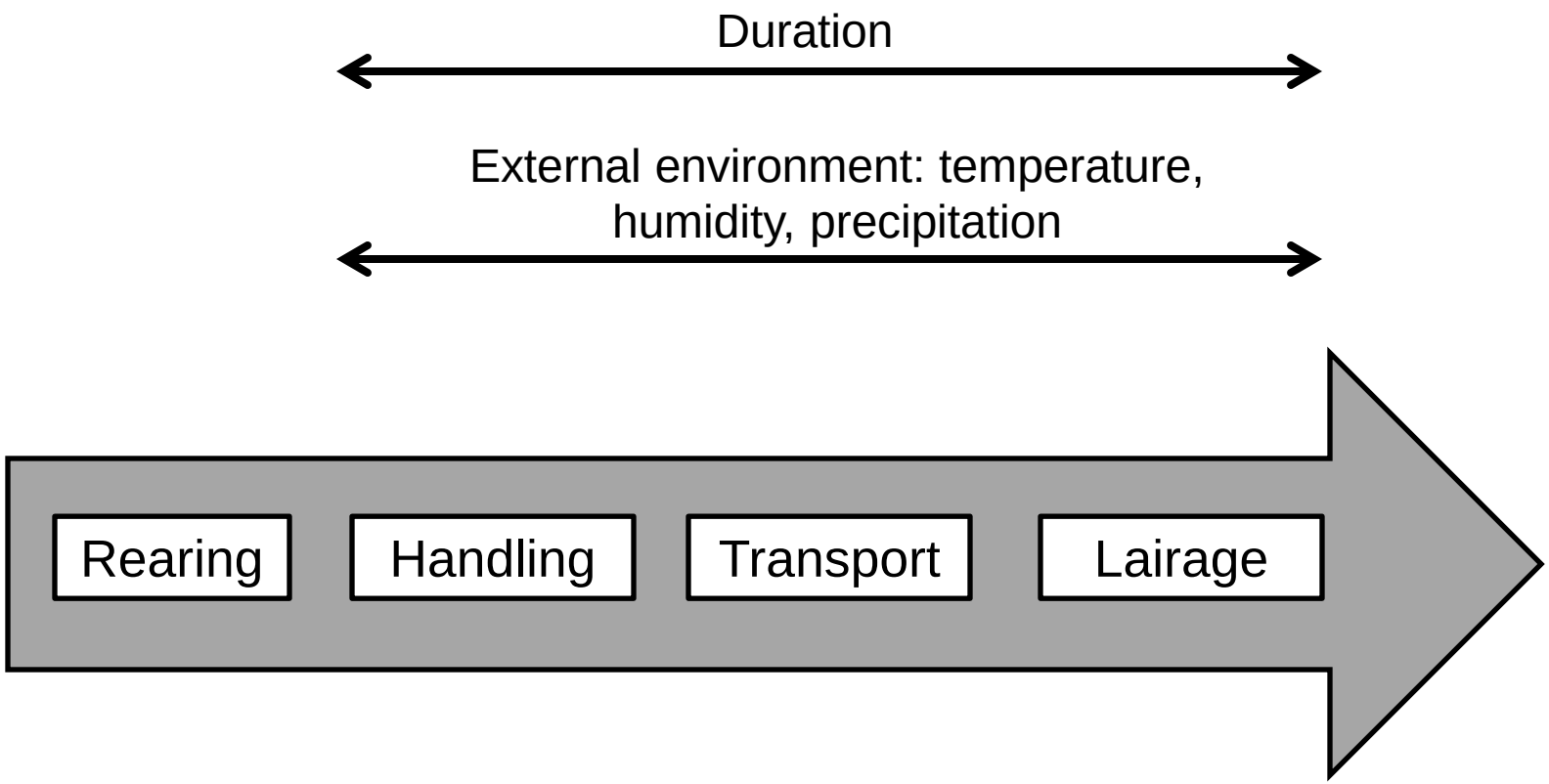
Mortality/Dead-on-arrivals (DOAs)

- Mortality can occur at any time after loading on-farm, during the journey to the processing plant or at the processing plant during lairage or in a holding barn.

Mortality/Dead-on-arrivals (DOAs)

- Economic loss and poor public image
- Meat quality from birds that survive problematic journeys likely to be reduced
- One indication of severity of animal welfare issues
- If death is quick and without suffering, not a welfare issue
- If prolonged and associated with suffering, such as pain and distress, it is a welfare concern.
- High mortality rates also indicate that the birds that survived will likely have suffered ill effects for part or all of the duration of the journey.

Summary of risk factors affecting % DOA during each pre-slaughter stage.



Multivariable analyses of slaughter records to identify risk factors for mortality: crates

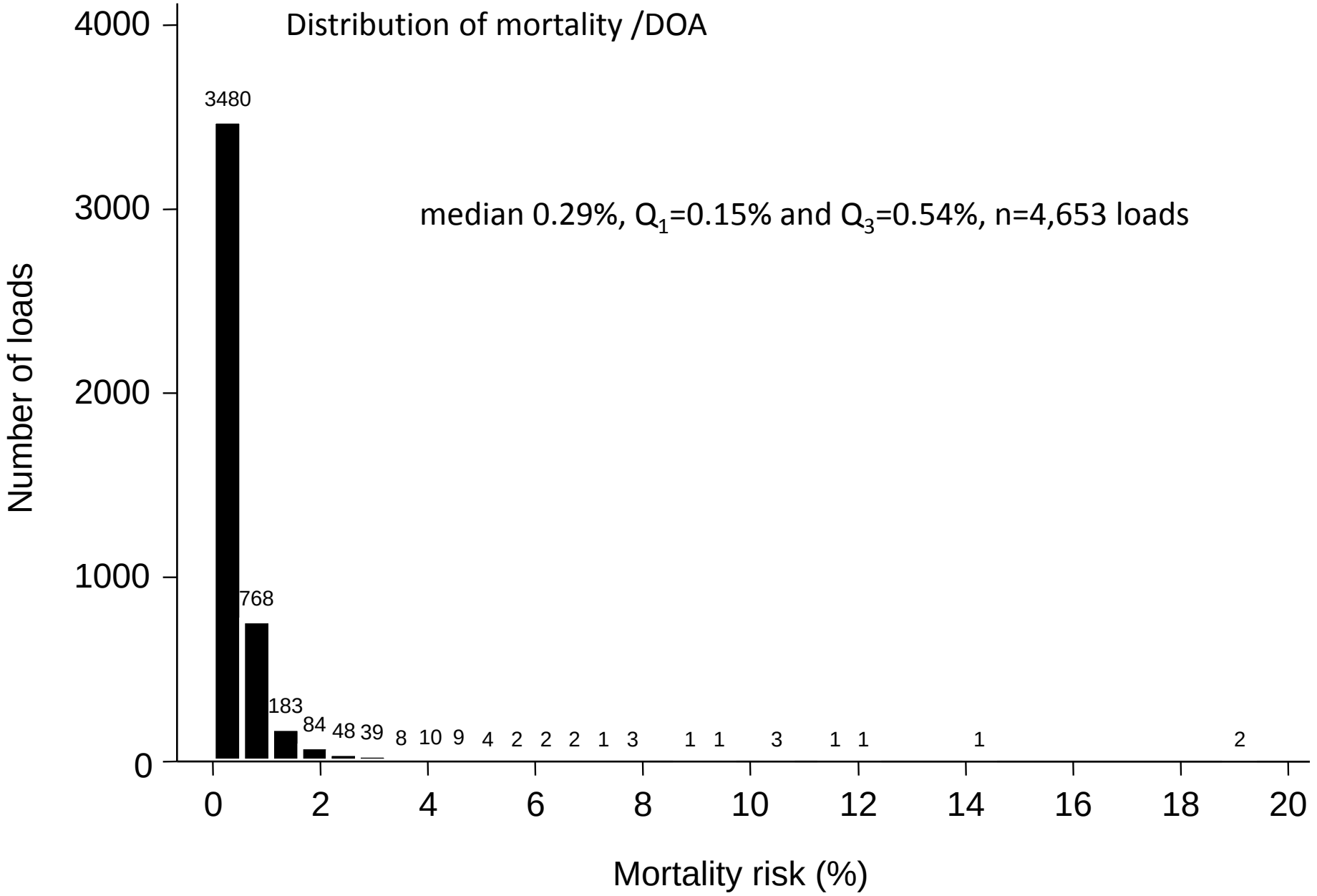
- Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208.
- Complex data
- Large number of risk factors
- Data modeling techniques used to
  - provide representations of the data and
  - show relationships between factors that influenced the mortality risk

Multivariable analyses of slaughter records to identify risk factors for mortality

- Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208.
- Plant provided data in the form of
  - digital spreadsheets
  - scanned forms containing handwritten records of
    - flock reports
    - driver reports
    - holding barn reports
  - for each trailer load of broiler chickens transported from each farm/producer to the plant from January 2009 until July 2010

Descriptive statistics Caffrey et al. 2017

Continuous variables	No. loads	Minimum	Q_1	Median	Q_3	Maximum
Rearing						
Mortality during rearing (%)	4,525	0.00	1.5	**2.0**	2.3	7.0
Loading, transport and holding						
Number of birds per load	4,652	80	5,990	**6,800**	7,524	12,720
Feed withdrawal before loading (h)	3,756	0.00	1.16	**3.16**	8.25	19.00
Loading duration (h)	4,614	0.20	1.40	**1.60**	1.80	5.20
Journey duration (h)	4,624	0.10	0.30	**8.50**	10.70	16.00
Holding duration (h)	3,669	0.00	1.20	**2.50**	3.70	11.80
Total duration (h)	3,639	1.20	5.60	**12.60**	14.90	23.50
Duration without feed (h)	3,642	3.70	14.50	**16.30**	18.20	24.00
Environment						
External temperature all stages (°C)	4,646	-33	-3	**5**	13	32
Trailer temperature during journey (°C)	2,770	-19	6	**12**	17	30
Trailer temperature during holding (°C)	3,153	-16	8	**13**	19	34



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Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208

Significant risk factors identified in a mixed effects linear regression model as influencing mortality risk

- Age x Sex interaction
- Weight
- Catching team
- Duration without feed before loading
- Journey duration
- Holding barn duration
- Season
- Crate stocking density x External temperature interaction
- Condition of birds on arrival

Risk factors affecting % DOA or bruised studied from plant data and by undertaking direct observations during on-farm loading and then carrying out multivariable analyses: modules

- Cockram, M.S., Dulal, K.J., Mohamed, R.A. and Revie, C.W. Risk factors for bruising and mortality of broilers during manual handling, module loading, transport and lairage. *Canadian Journal of Animal Science* https://doi.org/10.1139/CJAS-2018-0032
- Selected loads between 2014 and 2015 from 7 producers were included in the study

Descriptive statistics on broiler weight, age and health

Variable	No. of loads	Minimum	Q_1	Median	Q_3	Maximum
Bird						
Weight (kg)	212	1.66	2.14	**2.22**	2.43	2.72
Age (days)	212	30	35	**36**	38	39
Health						
Rearing mortality (%)	212	0.74	2.90	**3.22**	4.86	23.9
Total condemnations (%)	212	0.09	0.45	**0.65**	0.90	3.29
Condemnations due to abdominal oedema (%)	205	0.00	0.07	**0.14**	0.24	1.08
Condemnations due to liver condition (%)	205	0.00	0.01	**0.02**	0.03	0.53

Cockram, M.S., Dulal, K.J., Mohamed, R.A. and Revie, C.W. Risk factors for bruising and mortality of broilers during manual handling, module loading, transport and lairage. *Canadian Journal of Animal Science*

Descriptive statistics on loading

	No. loads	Minimum	Q_1	Median	Q_3	Maximum
Loading						
Duration of feed withdrawal before loading (h)	211	0.08	2.75	**3.95**	5.52	9.57
Duration of water withdrawal before loading (h)	210	0.05	0.98	**2.00**	3.83	7.33
Duration of loading (h)	212	0.57	0.92	**1.08**	1.23	2.25
Speed of loading (no. birds/catcher/hour)	211	146	643	**751**	887	1,445
Stocking density (kg/drawer)	212	64.6	74.1	**77.0**	79.5	84.3
No. of birds loaded/trailer	212	3,292	6,010	**6,600**	6,840	8,320
External temperature (°C)	211	-22.6	-2.2	**6.1**	12.4	22.3
Trailer temperature (°C)	64	-14.7	6.6	**11.5**	15.1	22.4

Cockram, M.S., Dulal, K.J., Mohamed, R.A. and Revie, C.W. Risk factors for bruising and mortality of broilers during manual handling, module loading, transport and lairage. *Canadian Journal of Animal Science*

Descriptive statistics on journey and lairage

	No. loads	Minimum	Q_1	Median	Q_3	Maximum
Journey						
Journey duration (h)	207	4.33	5.42	**5.83**	6.25	8.67
Total duration of stops during journey (h)	192	0.07	0.20	**0.33**	0.50	0.50
Trailer temperature (°C)	88	-9.4	9.5	**13.2**	15.9	23.0
Lairage						
Lairage temperature (°C)	211	11.2	15.2	**16.0**	16.9	26.8
Lairage duration (h)	201	0	0.83	**1.59**	2.52	5.12
Total duration (all stages) (h)	206	6.23	7.75	**8.62**	9.47	11.70

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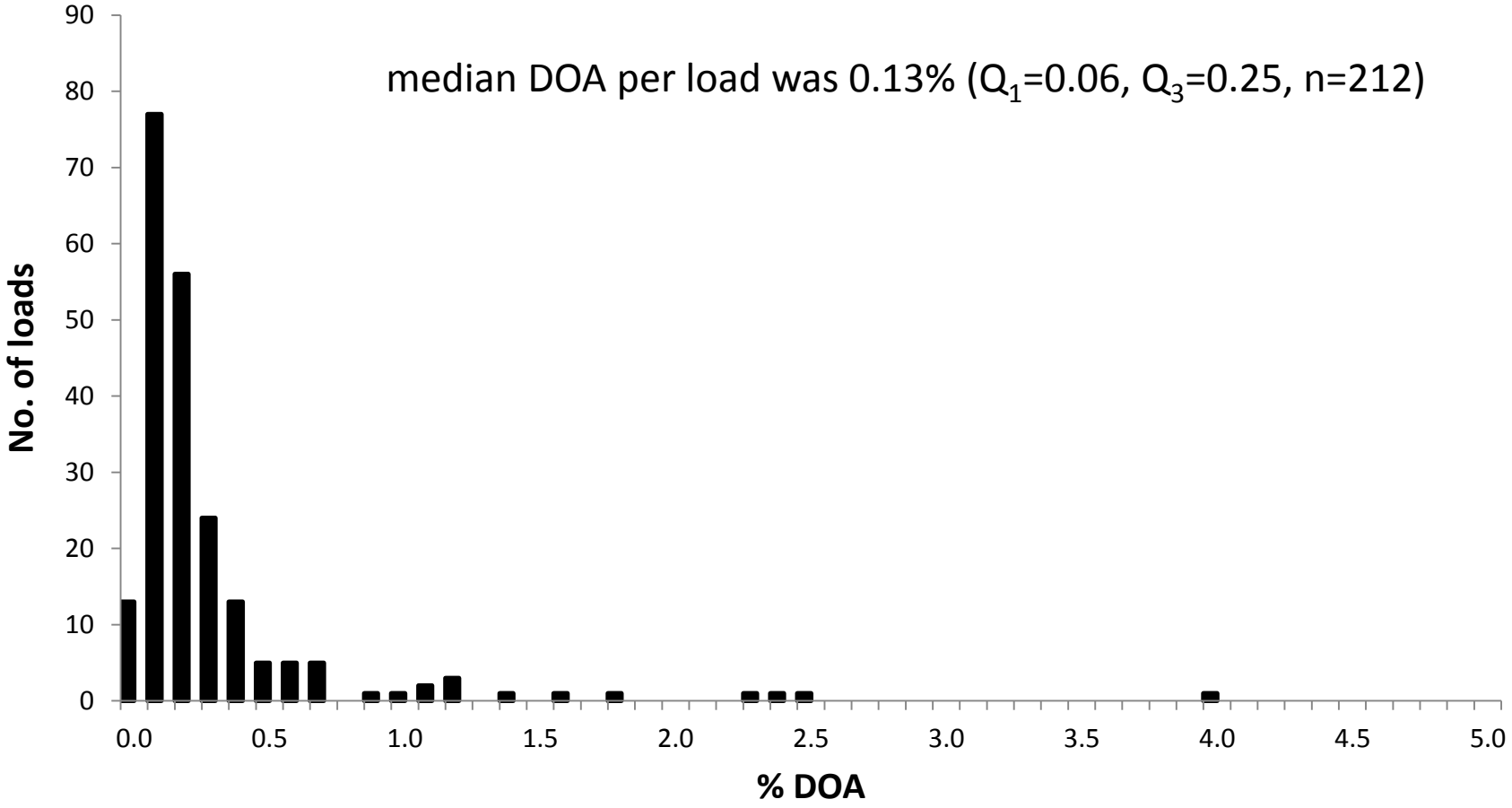

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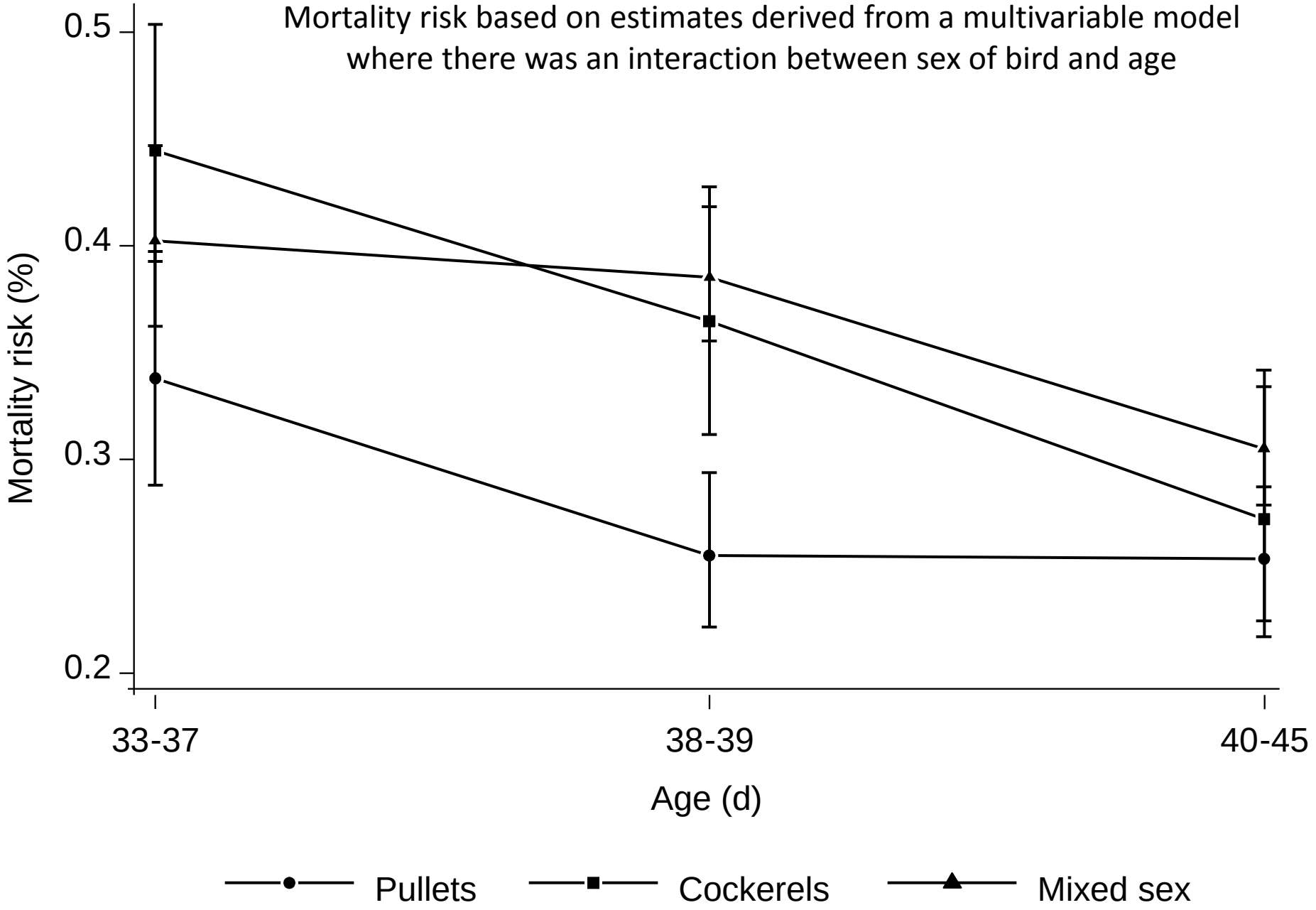
Significant risk factors identified in a mixed effects linear regression model as influencing mortality risk

- Weight
- Rearing mortality
- Duration without feed before loading >6 h
- Speed of loading
- Total duration x season interaction

Bird factors

Increased risk

- Sex (cockerels versus pullets)
  - In heat, pullets have lower body temperature rise
  - Cockerels heavier than pullets
- Age (but in cold can be beneficial)
- Weight
  - Lighter birds less risk from heat stress and femoral hip dislocation when carried



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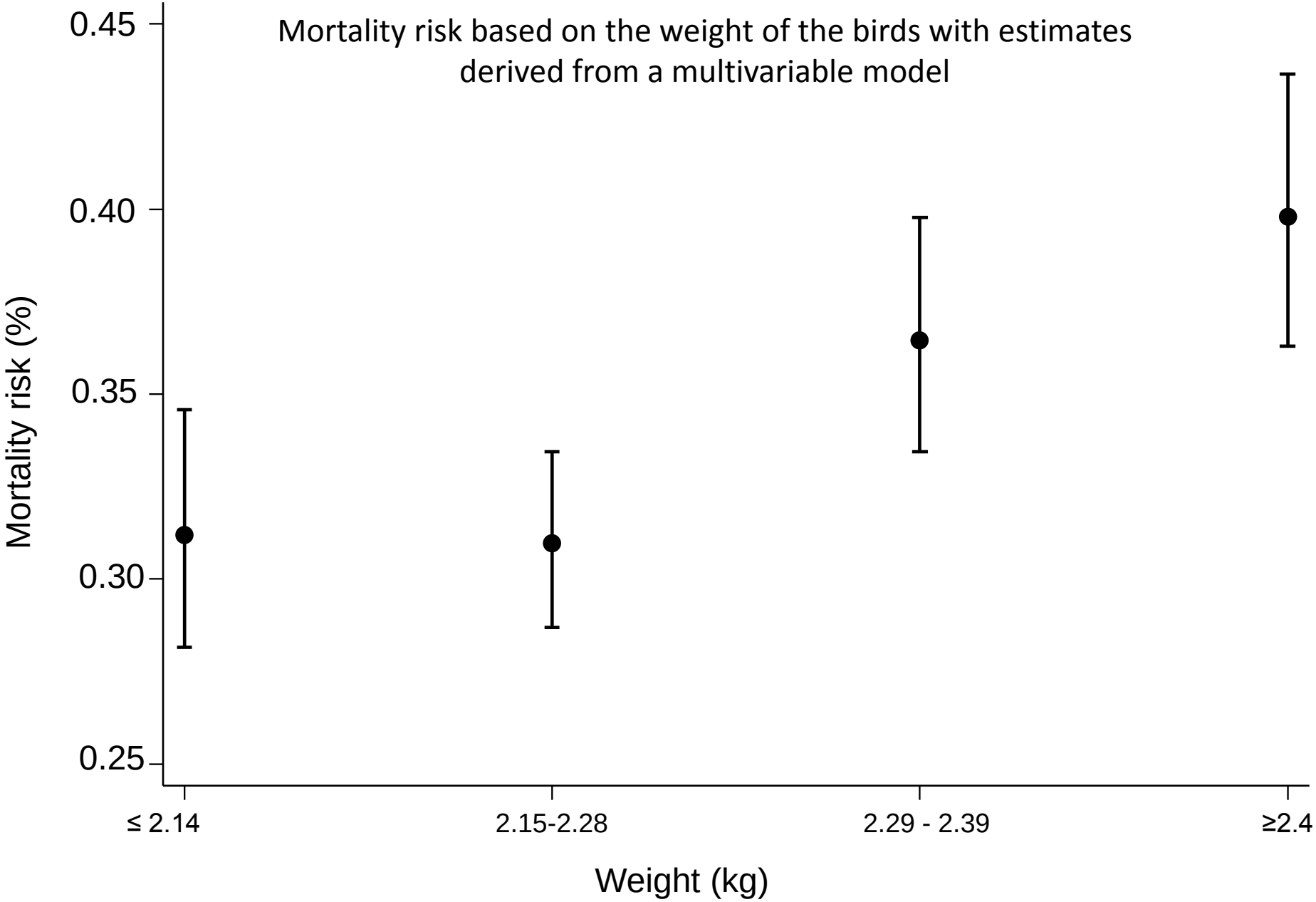

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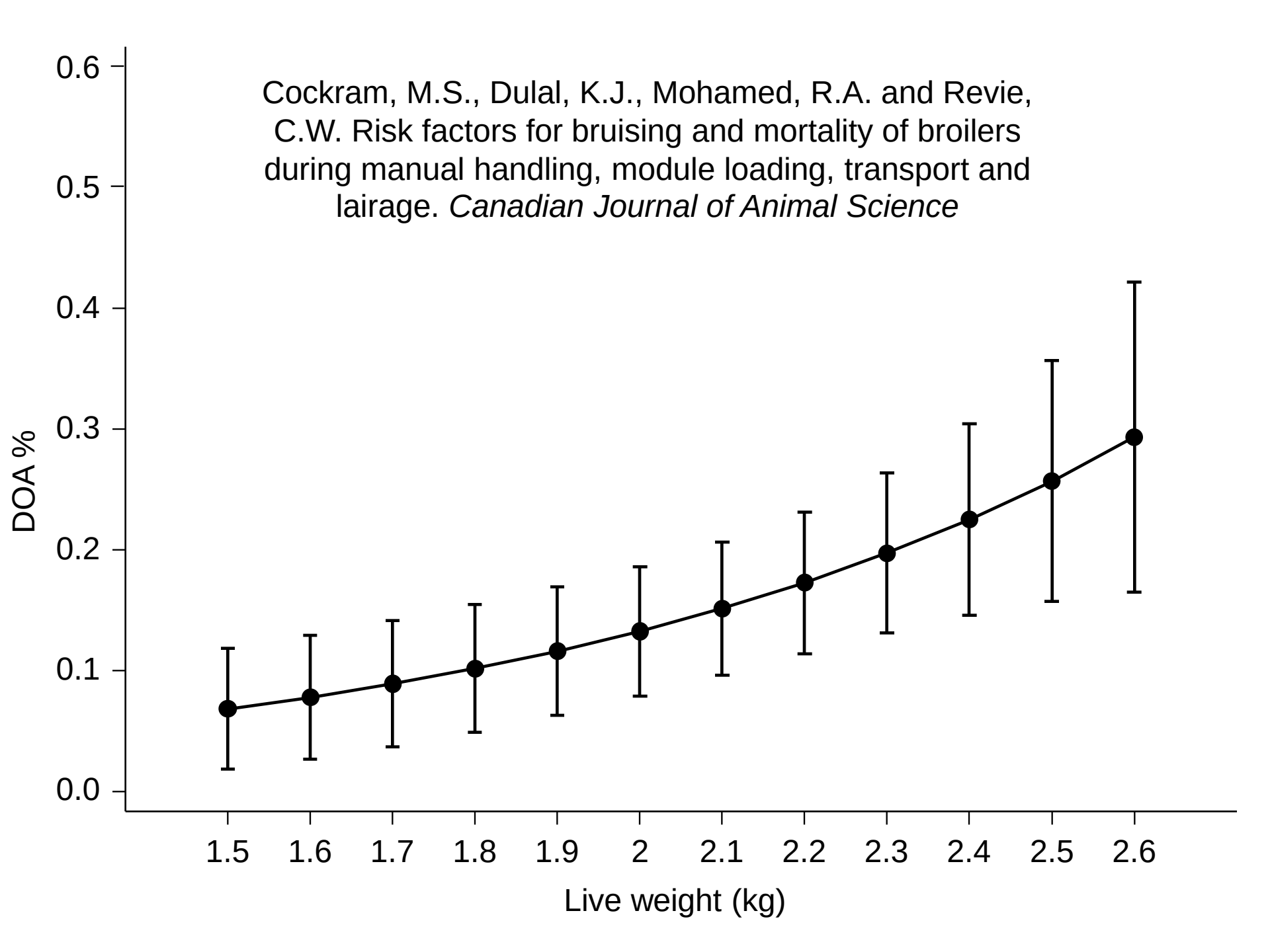
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DOA %
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
2.6
Live weight (kg)

Health

Assessed

- Health status during rearing
- Pathology in DOAs
- Pathology in slaughtered birds condemned as not fit for human consumption

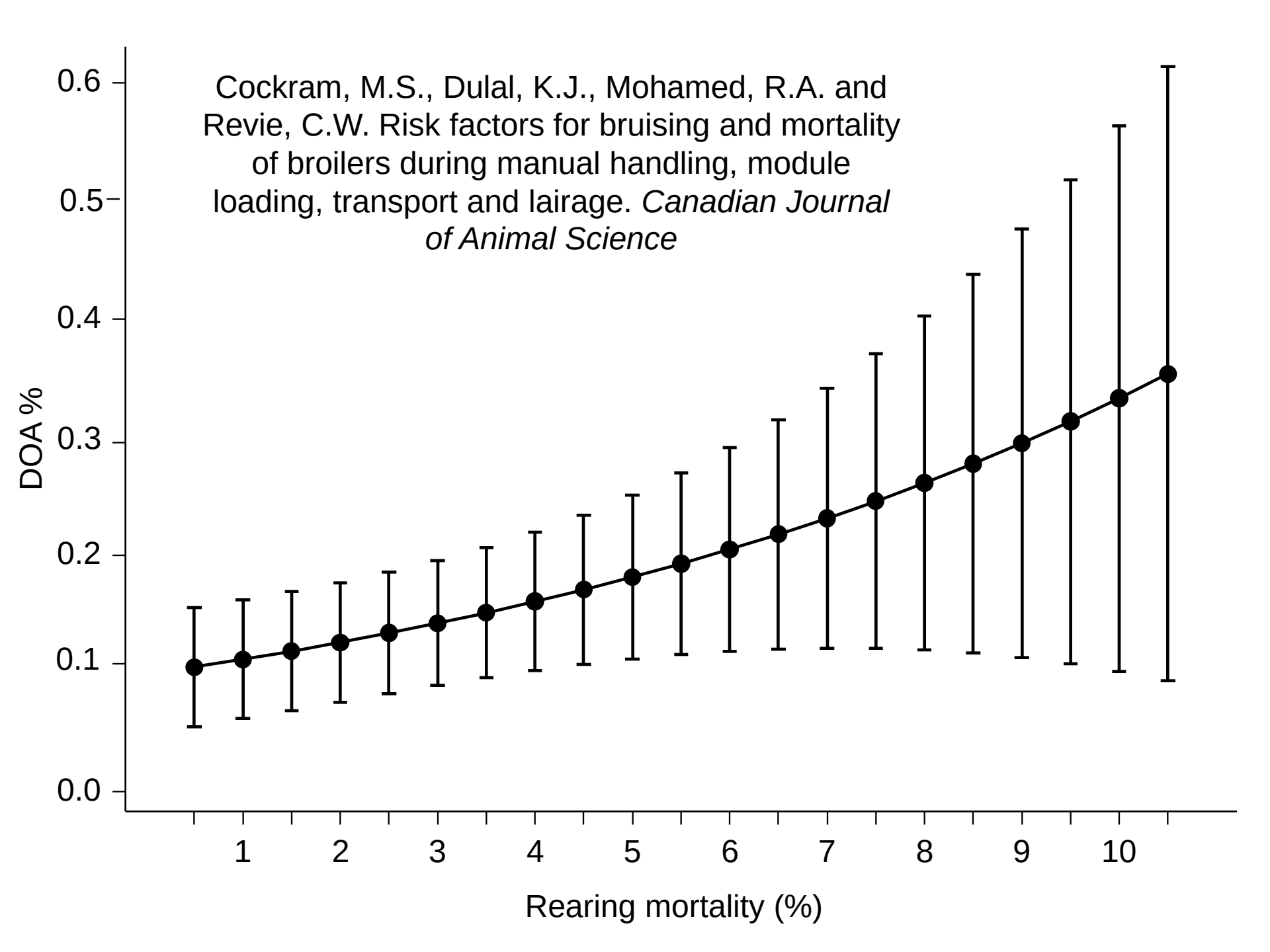
Health

- If major health problems during rearing some birds will die
  - recorded as the % mortality during rearing

  but some of the birds will survive.
- These birds may have been weakened and/or still have pathology that affects their physiological ability to respond to handling and transport to the extent that they are more likely to die
- In one study in Canada, where the mortality during rearing was 6.9%
  - Significant effect of rearing mortality on % DOA
  - Gross pathological lesions identified in about half of the birds that were DOA

Health

- Significant correlation between mortality during rearing and % DOA
- When rigorous culling to remove unfit birds included in the % mortality during rearing; negative relationship with % DOA.
- Significant relationships between
  - (a) % DOA and % of birds condemned after slaughter as not fit for human consumption
  - (b) % mortality during rearing and the % of birds condemned after slaughter as not fit for human consumption.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DOA %
0.0
0.1
0.2
0.3
0.4
0.5
0.6
1
2
3
4
5
6
7
8
9
10
Rearing mortality (%)

Health

- Cardiovascular disease common in broilers during rearing
- One study in Norway identified that of the mortalities that occurred during 3 days before transport
  - 36% sudden death syndrome (acute heart failure following ventricular arrhythmias precipitated by stressors)
  - 18% ascites
  - 28% endocarditis.
  - Lung congestion more prevalent in DOAs (57% of DOAs) than in broilers that died on the farm (38% of the deaths on-farm during the 3 days before transport).
-

Health

- Heart and lung size in proportion to body weight has decreased in modern broiler strains
  - effect more apparent in older and heavier birds
- If the heart has to work harder than normal to maintain effective blood flow throughout the body, a bird can develop chronic congestive heart failure.
- Fluid can collect in the lungs and abdomen (ascites) resulting in respiratory difficulties.
- One study showed that the prevalence of ascites was greater in DOAs than in those that survived transport and were subsequently slaughtered).
- In Canada
  - acute heart failure in 36% of DOAs
  - air sacculitis/pneumonia in 1%
  - chronic heart failure/ascites in 12%

Health

- Broilers can be weakened due to infectious diseases causing pathophysiological changes that place them at a greater risk of mortality during transport
- In one study in Denmark, septicaemia or systemic infections present in 4% of DOAs
- Skeletal disorders causing lameness can reduce access to feed and water and this might affect ability to cope with prolonged periods without feed and water.

Catching and handling

- Can cause trauma resulting in injury and death.
- In some studies, injury present in 30-35% of post-mortem examinations of DOAs
  - fractures
  - dislocations
  - ruptured liver
  - head trauma.
- Variation between catching teams can affect
  - % DOA and
  - % of birds with bruised wings or breasts.

Catching and handling

- Depending on genetics, experience and environmental factors, broilers can be fearful of humans resulting in withdrawal during approach and raised plasma corticosteroid concentration.
- Catching, lifting, holding and carrying a broiler inverted by its legs can cause wing flapping and struggling
- When birds are dropped into the crate or module, they can flap and injure their wings
- One study showed significant association between the % of broilers observed to be lying on their back after placement into modules and the % DOA.
- With greater weight increased risk of leg and wing damage.

Categorisation of loading arrangements

Loading category	Floor	Module placement	No. of loads	Description
1	Lower	Inside	77	Modules moved by forklift entering through main barn doors
2	Upper	Inside	73	Modules moved through one of several side doors by forklift remaining outside of barn
3	Lower/ upper	Outside	23	Modules placed outside near one of several side doors either on a stand or the ground. Birds transferred by handlers to one or more handlers standing outside, near the modules, who then placed the birds in the module drawers.
4	Lower/ upper	Mixed	38	Mixed or unclassified

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Handling categories used to characterise the manner in which birds were placed in module drawers by handlers

Handling category	Description on how handler placed their birds into the drawer
Movement 1	Moved arm slowly and released the birds while hand was less than one bird length outside of the drawer
Movement 2	Horizontal movement of arm and released the birds while hand was at least one bird length outside of the drawer
Movement 3	Released the birds vertically while hand was at least one bird length above the drawer
Movement 4	Moved arm in a rapid curved movement and released the birds while hand was at least one bird length outside of the drawer

Effect of loading category on bird handling

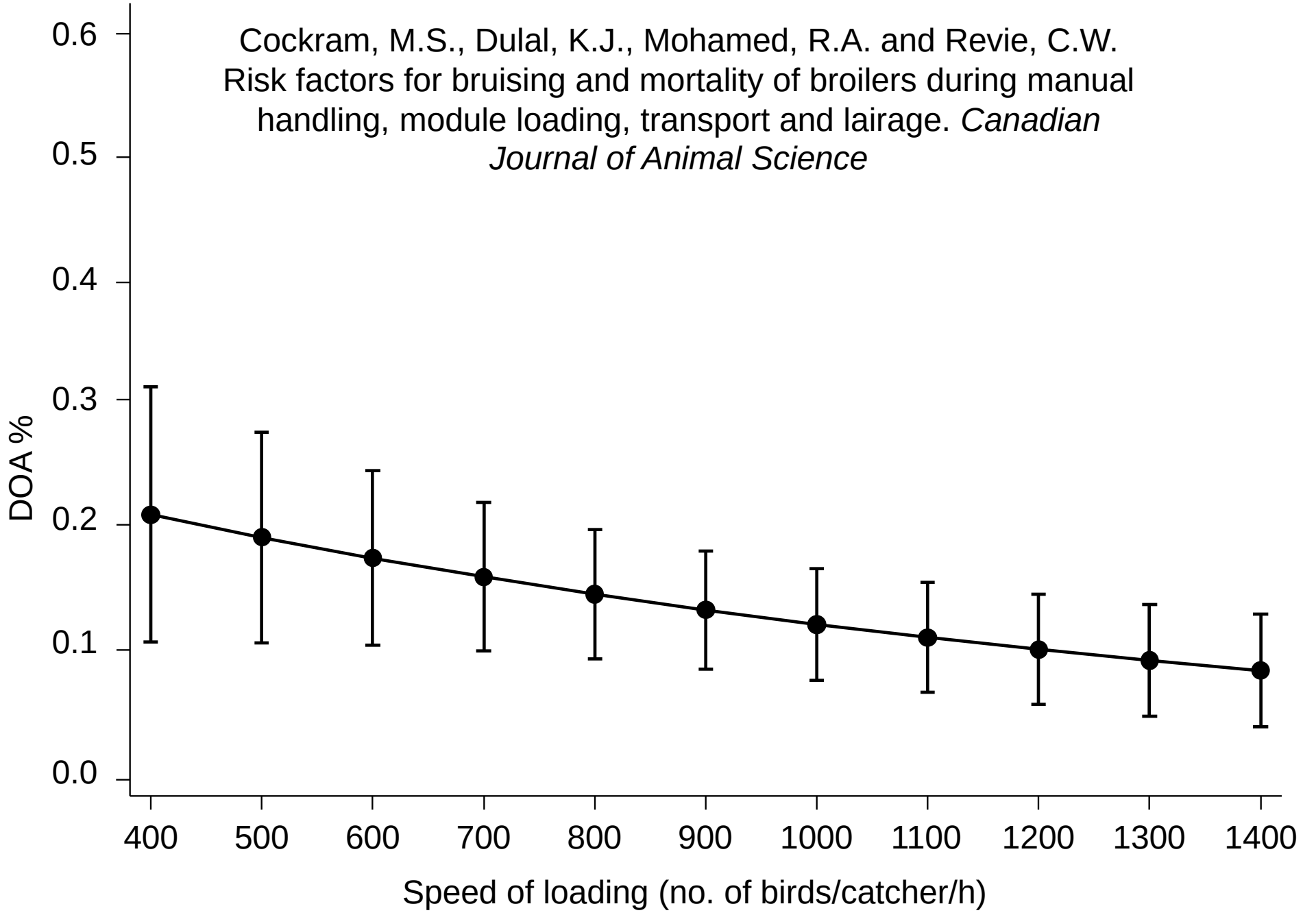
Loading category	1			2			3			4		
Floor	Lower			Upper			Lower/upper			Lower/upper		
Module placement	Inside			Inside			Outside			Mixed		
No. of loads	77			73			23			38		
	Q_1	Median	Q_3	Q_1	Median	Q_3	Q_1	Median	Q_3	Q_1	Median	Q_3
Speed (no. of birds/catcher/h)	638	730	853	422	790	926	457	686	859	569	683	808

Effect of loading category on bird handling

Loading category	1			2			3			4		
Floor	Lower			Upper			Lower/upper			Lower/upper		
Module placement	Inside			Inside			Outside			Mixed		
No. of loads	77			73			23			38		
	Q_1	Median	Q_3	Q_1	Median	Q_3	Q_1	Median	Q_3	Q_1	Median	Q_3
% of total no. of movements observed												
Movement 1	78	90	97	79	85	93	82	94	99	84	89	96
Movement 2	3	5	15	3	7	10	1	2	7	3	5	11
Movement 3	0	0.5	4	1	2	8	0	0	4	0	0.5	2
Movement 4	0	0	3	0.2	3	5	0	0	1	0	1	2

Effect of loading category on bird handling, % DOA and % bruising

Loading category	1			2			3			4		
Floor	Lower			Upper			Lower/upper			Lower/upper		
Module placement	Inside			Inside			Outside			Mixed		
No. of loads	77			73			23			38		
	Q_1	Median	Q_3	Q_1	Median	Q_3	Q_1	Median	Q_3	Q_1	Median	Q_3
Wing flapped (% of total no. of movements observed	3	6	9	4	6	9	1	2	3	4	6	9
% DOA	0.06	0.14	0.26	0.06	0.14	0.27	0.04	0.06	0.14	0.08	0.15	0.30
% wing bruising	1	2	4	1	2	3	1	2	4	1	2	4
% leg bruising	0	0	0	0	0	0	0	0	0	0	0	0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DOA %
0.0
0.1
0.2
0.3
0.4
0.5
0.6
400
500
600
700
800
900
1000
1100
1200
1300
1400
Speed of loading (no. of birds/catcher/h)

Thermal conditions

- Environmental conditions affect % DOA
- Conditions experienced by the birds dependent on
  - ambient environmental conditions
  - manual adjustments to the ventilation
  - choice of stocking density.

Thermal conditions

- Trailer temperature during a journey is not uniform throughout the vehicle and extremes of thermal conditions are possible within the load
- Pattern of ventilation and trailer temperatures within a load depend on factors such as
  - vehicle design
  - arrangement of the crates or modules
  - ventilation configuration selected by the driver.

Thermal conditions

- Large numbers of birds transported at high stocking density produce metabolic heat and moisture during a journey.
- Some of this heat and moisture is removed by airflow through and between the crates or modules produced by
  - external pressure differences during vehicle motion
  - wind and
  - passive thermal buoyancy.
- Highest trailer temperatures occur when vehicle is stationary

Thermal conditions

- When heat and humidity are not effectively removed by the ventilation
- Localised “thermal cores” created in which the temperature and humidity are sufficiently high to put birds at risk of thermal distress
- As air enters a moving trailer mainly at the rear and then as it is heated by the birds, it rises, ‘thermal cores’ tend to occur in the top and front sections of a trailer.

Thermal conditions

- During warm and dry conditions, maximum ventilation is provided by leaving as much as possible of the surface area on the sides of the vehicle open.

Thermal conditions

- In cold conditions, birds require protection from the cold external temperatures
  - essential that the birds kept near the sides of the vehicle do not become wet or exposed to excessive air movement

DOAs

	Curtains open	Curtains closed
DOA %	0.12	0.93
% of DOAs		
Health	70.6	0.9
Injury	28.3	4.3
Thermal	1.1	94.9

Hunter, R. R., Mitchell, M. A. and Matheu, C. 2001. Mortality of broiler chickens in transit – correlation with the thermal micro-environment. Livestock Environment VI: Proceedings of the 6th International Symposium (21-23 May 2001), Louisville, Kentucky, USA 542-549.

Thermal conditions

- In cold conditions
- precipitation
- wet road conditions
- excessive wind

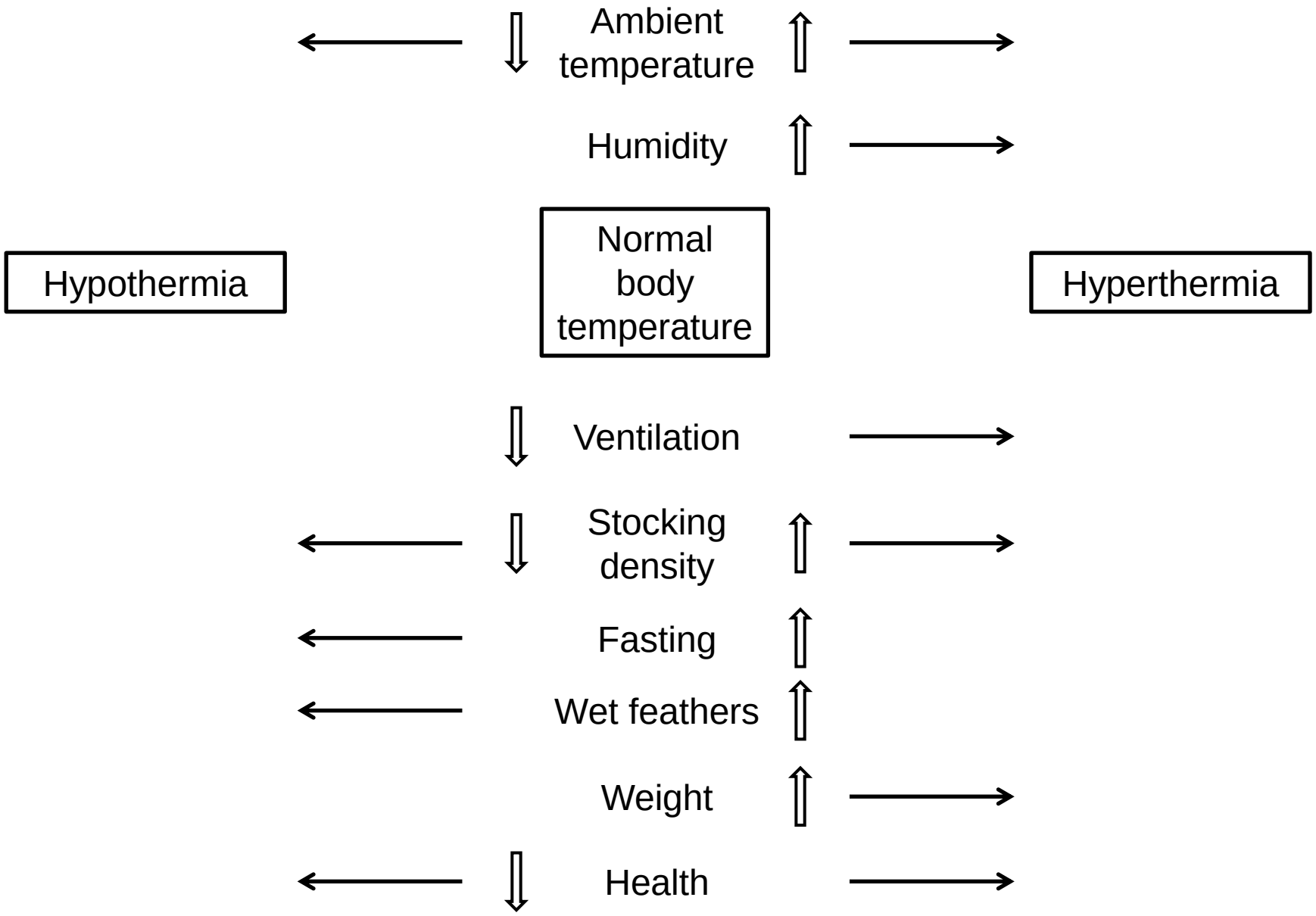
- Driver uses side protection (e.g. screens, curtains, tarpaulins) around part or all of the vehicle/trailer.

- This reduces the ventilation flow and the internal trailer temperature rises.

- In extremely cold conditions this temperature rise can be beneficial in that it raises the internal temperature above the potentially lethal cold external temperature.

- However, in a closed or partially closed ventilation configuration, internal thermal cores consisting of pockets of raised temperature and moisture from the birds can occur at one or more locations within the vehicle

Summary of potential interactions between temperature and humidity, and management and bird factors affecting the risk of mortality due to hypothermia and hyperthermia.



Heat stress

- Effect of high temperatures on mortality risk of mortality affected by
  - relative humidity
  - convective airflow
  - wetting of the birds (evaporative cooling)
  - duration of fasting
  - stocking density
  - ability of the birds to lift and spread their wings, and
  - age and weight of the birds

Heat stress

- Main mechanism available to birds to lose heat is evaporation of water via
  - respiratory tract and
  - through the skin
- As air temperatures increases, the respiration rate increases and eventually panting occurs.
- Ability of the bird to lose heat from evaporative cooling is dependent on a gradient in temperature and/or moisture between the bird and the surrounding environment

Heat stress

- Charts have been constructed that indicate the combined effect of relative humidity and temperature
- safe zones (apparent equivalent temperature of ≤ 40^{o}C)
- alert and danger (apparent equivalent temperature of ≥ 65^{o}C)
- Apparent equivalent temperature
  - ≥70^{o}C results in hyperthermia (≥ 1^{o}C rise in body temperature)
  - ≥80^{o}C could induce fatal hyperthermia

Relationship between temperature and humidity

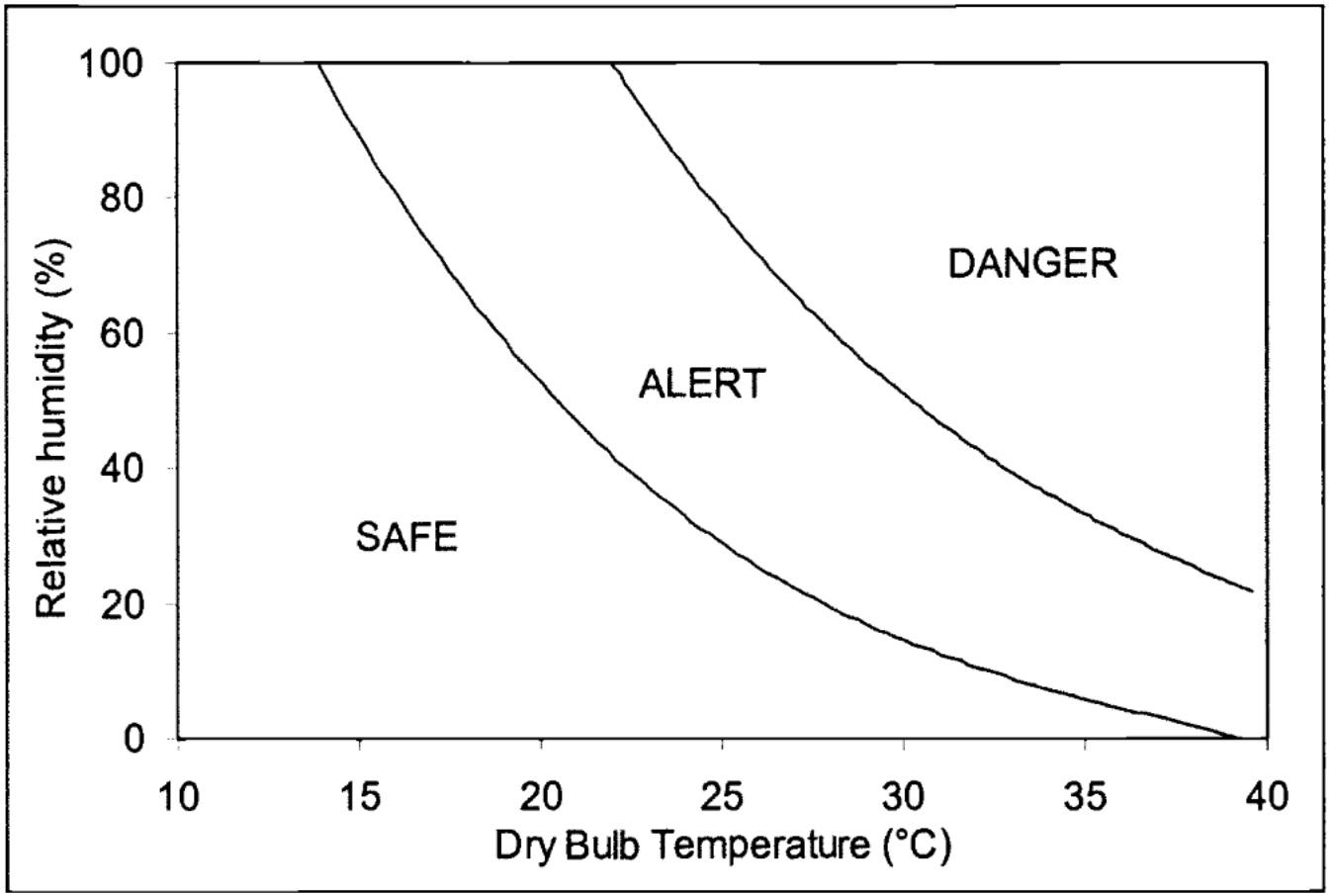


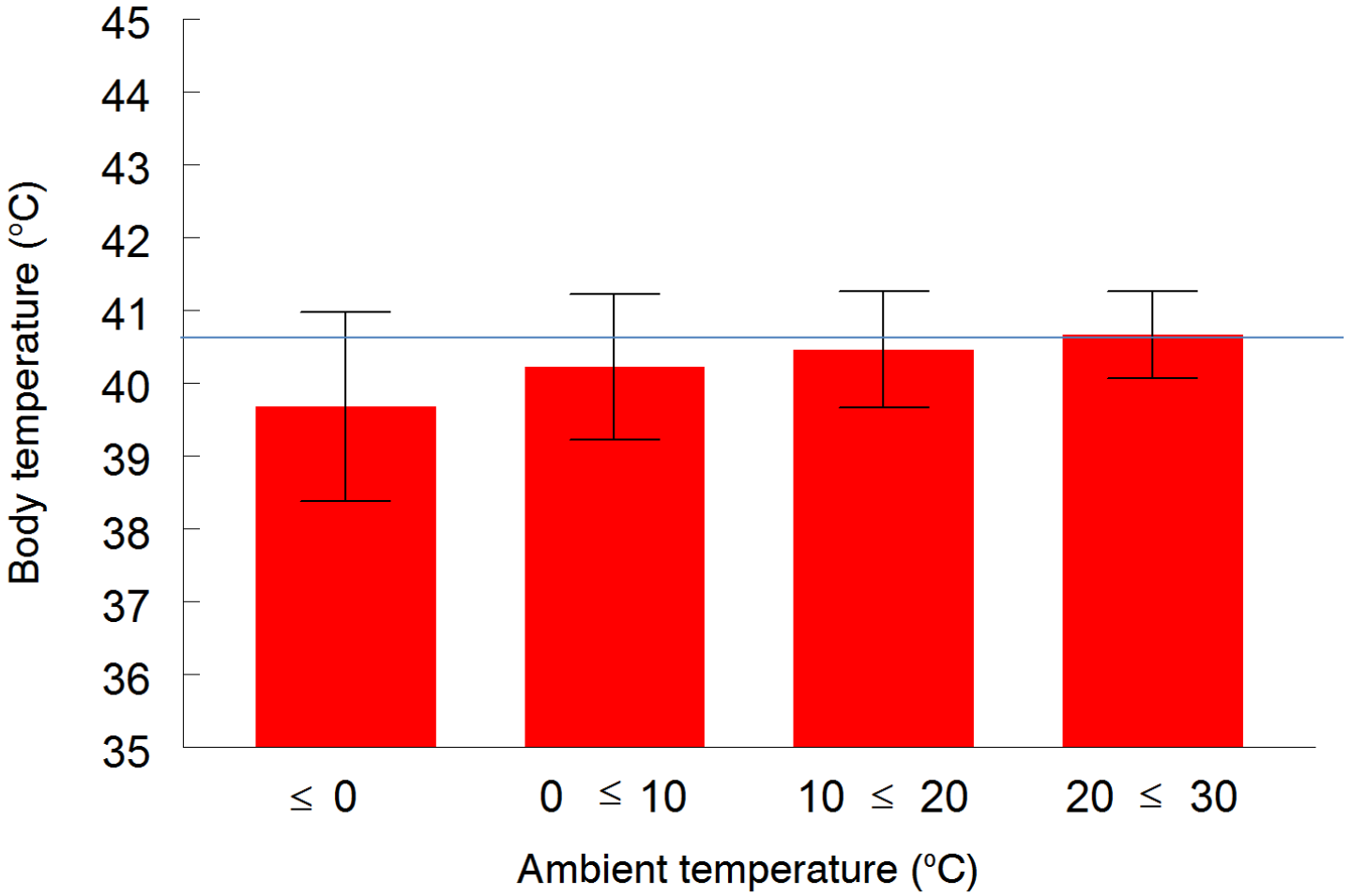
Figure 1 "Thermal Comfort Zones" for broiler transport Safe limit AET = 40°C ; danger limit AET = 65°C or greater

Mitchell and Kettlewell 2004. Proc. Aust. Poult. Sci. Sym. 16. 175.

Cold stress

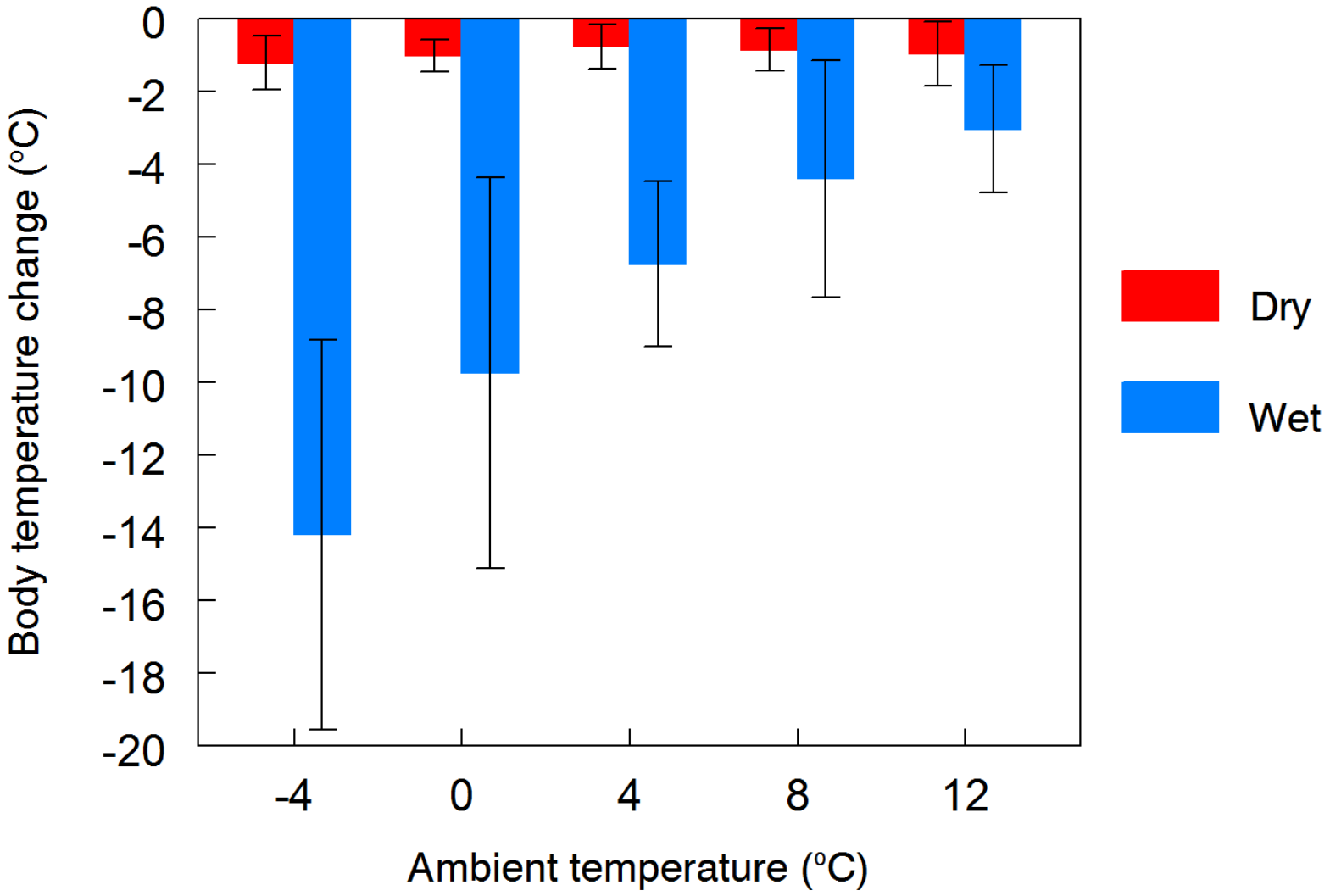
- Lower critical temperature of broilers at the time of slaughter is about 24^{o}C
- At temperatures below this, birds must reduce their heat loss and/or increase heat production to maintain their body temperature.
- If environmental temperature exceeds the capacity of the birds to maintain their body temperature, they become hypothermic and they will die when their body temperature decreases to 19 or 20^{o}C

Effect of ambient temperature on body temperature of broilers transported for 3-4 h



Adapted from Dagar et al 2010 Poultry Science 89: 1033-1041

Effect of wetting broilers with a mist spray and an air velocity of 0.7 m/s for 3 h

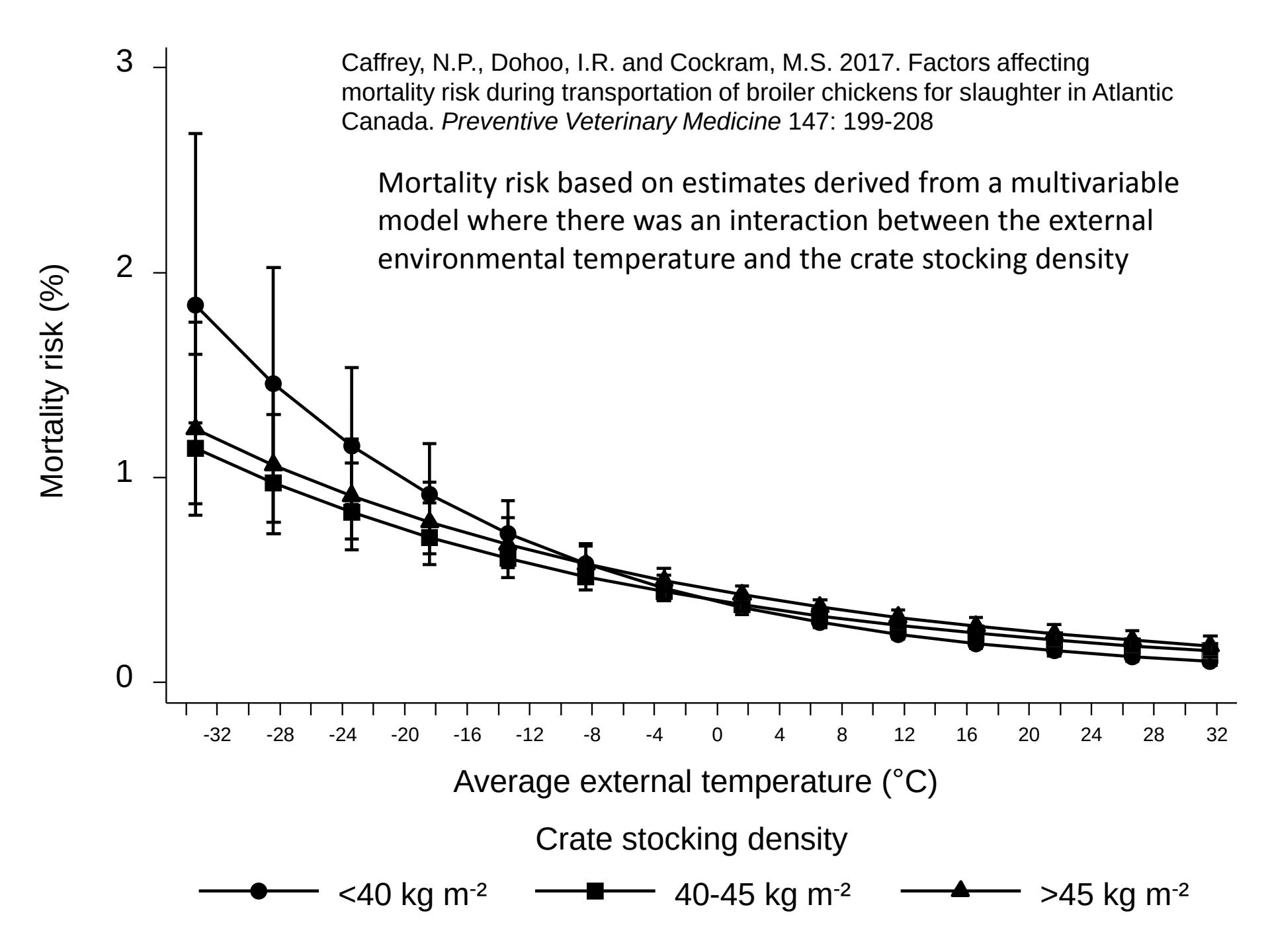


Adapted from Hunter et al. 1999. British Poultry Science 40: S48-S49.

Cold stress

When broilers are exposed to cold temperatures

- place their head and feet under their body
- huddle
- ptiloerection
- vasoconstriction
- shiver and
- Increase their metabolic rate
- Utilize glycogen stored in the liver and muscles and mobilise fat reserves to provide sources of energy to maintain increased metabolic rate


Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208
Mortality risk based on estimates derived from a multivariable model where there was an interaction between the external environmental temperature and the crate stocking density
Mortality risk (%)
0
1
2
3
-32
-28
-24
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
28
32
Average external temperature (°C)
Crate stocking density
<40 kg m-2
40-45 kg m-2
>45 kg m-2

Lairage/Holding barn conditions

% DOA affected by thermal conditions within the crates or modules.

- Type of handling system and lairage design can influence thermal environment
- If birds remain in crates on the trailer, provision of adequate ventilation to all of the birds in the load can be challenging.
- Temperature within the crates can rise above the external temperature and cause hyperthermia.
- In warm conditions, evaporative cooling in addition to fan ventilation can be beneficial.
- One advantage of a modular handling system over crates is that modules can be unloaded and placed at appropriate locations in a lairage
- Provision of adequate shade and insulation from solar radiation, protection from wind, precipitation and extremely cold temperatures would reduce % DOA.

Duration of pre-slaughter stages
Duration without feed before loading

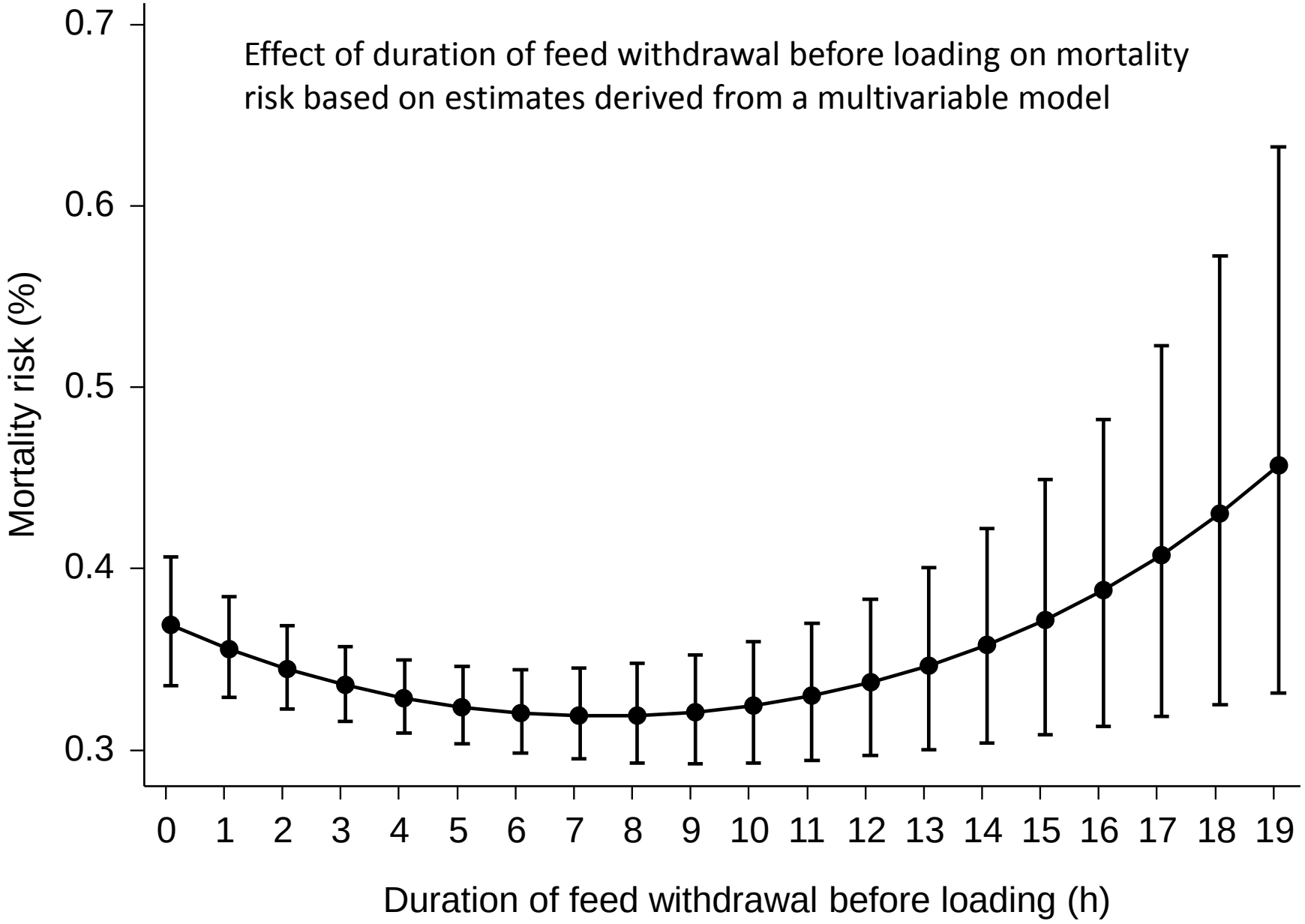
- Feed withdrawal before loading is practised to
  - allow time for the digestive tract to empty before processing
  - leaving less ingesta and faeces for potential carcass contamination.
  - Significant reduction in the frequency of defaecation and weight of gut contents occurs within 4-6 h of fasting

Duration of pre-slaughter stages
Duration without feed before loading

- Increasing period of feed withdrawal above 8-9 h can be detrimental due to the development of a negative energy balance and decreased ability to cope with cold temperatures
- Fasting for 10 h causes significant reduction in the liver glycogen concentration
  - In 7-week-old broilers, fasted at 21^{o}C, some liver glycogen was present after 3h, but after 6 h, liver glycogen concentration is negligible
- Fasting for 12 h reduces the liver lipid content

Duration of pre-slaughter stages
Duration without feed before loading

- During cold exposure, e.g. 0 to -17^{o}C, fasted birds show
  - greater reductions in blood glucose concentration and liver glycogen concentration than those kept at 20 to 22^{o}C
  - and are at an increased risk of hypothermia
- However, in warmer temperatures, their metabolic heat production declines during prolonged fasting and this can be beneficial.



Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208

Duration of pre-slaughter stages
Duration without water

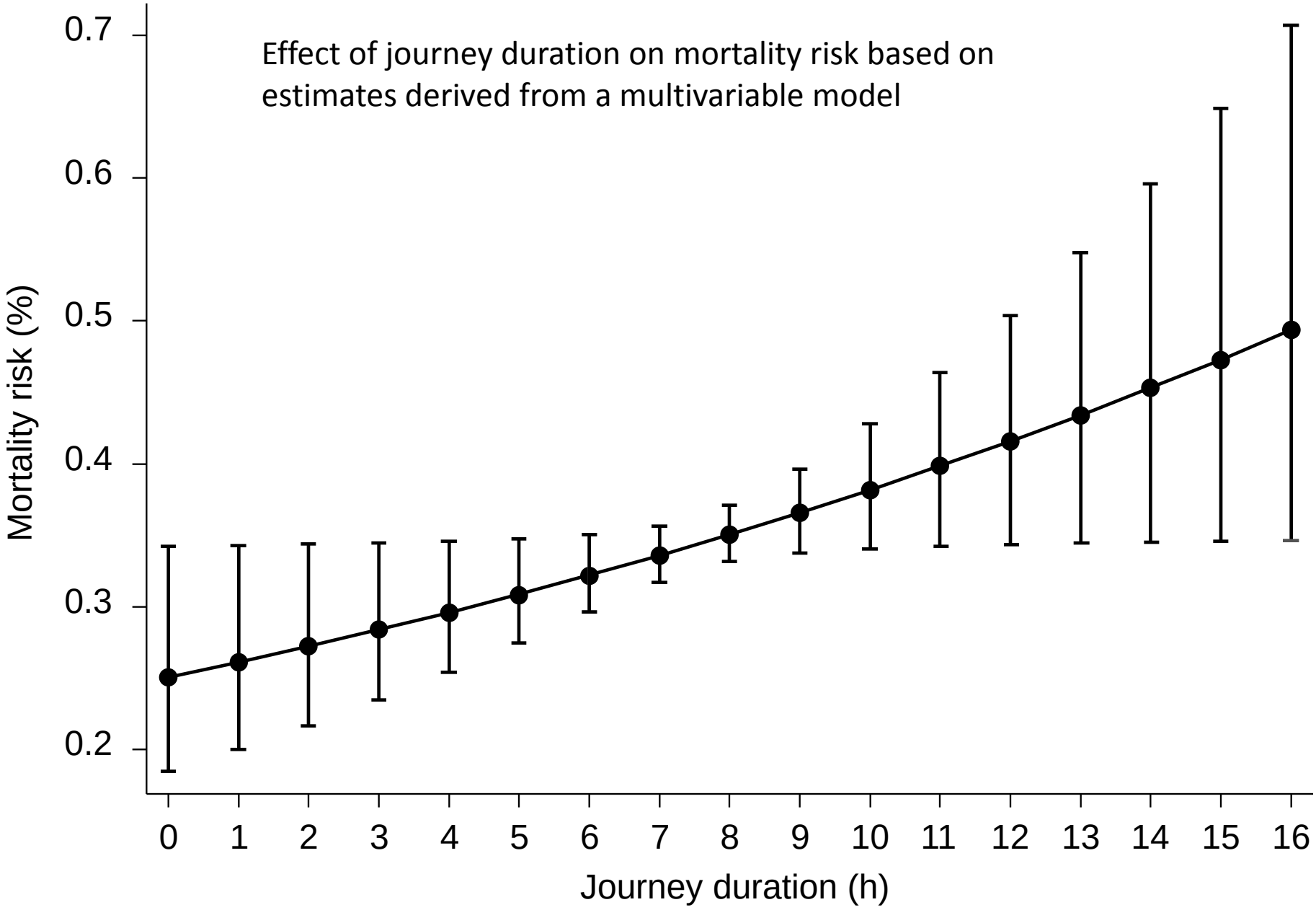
- Current advice is to provide unlimited access to water for as long as possible before loading and remove water only when necessary.
- Birds have efficient mechanisms for dealing with prolonged water deprivation thereby avoiding significant reductions in plasma volume.
- Period of water withdrawal that is normally associated with loading, transport and lairage is unlikely in itself to cause sufficient dehydration to cause death

Duration of pre-slaughter stages
Duration without water

- However, broilers are likely to experience increased thirst after 6 h without water
- Some DOAs are dehydrated and this could be associated with difficulty accessing drinking water during rearing due to health issues such as lameness
- Consequences of prolonged periods without access to water might be more severe when birds are exposed to high temperatures, as they use water for evaporative cooling via respiration
- When exposed to high temperatures, birds without access to water for prolonged periods are likely to be at increased risk of dehydration and hyperthermia

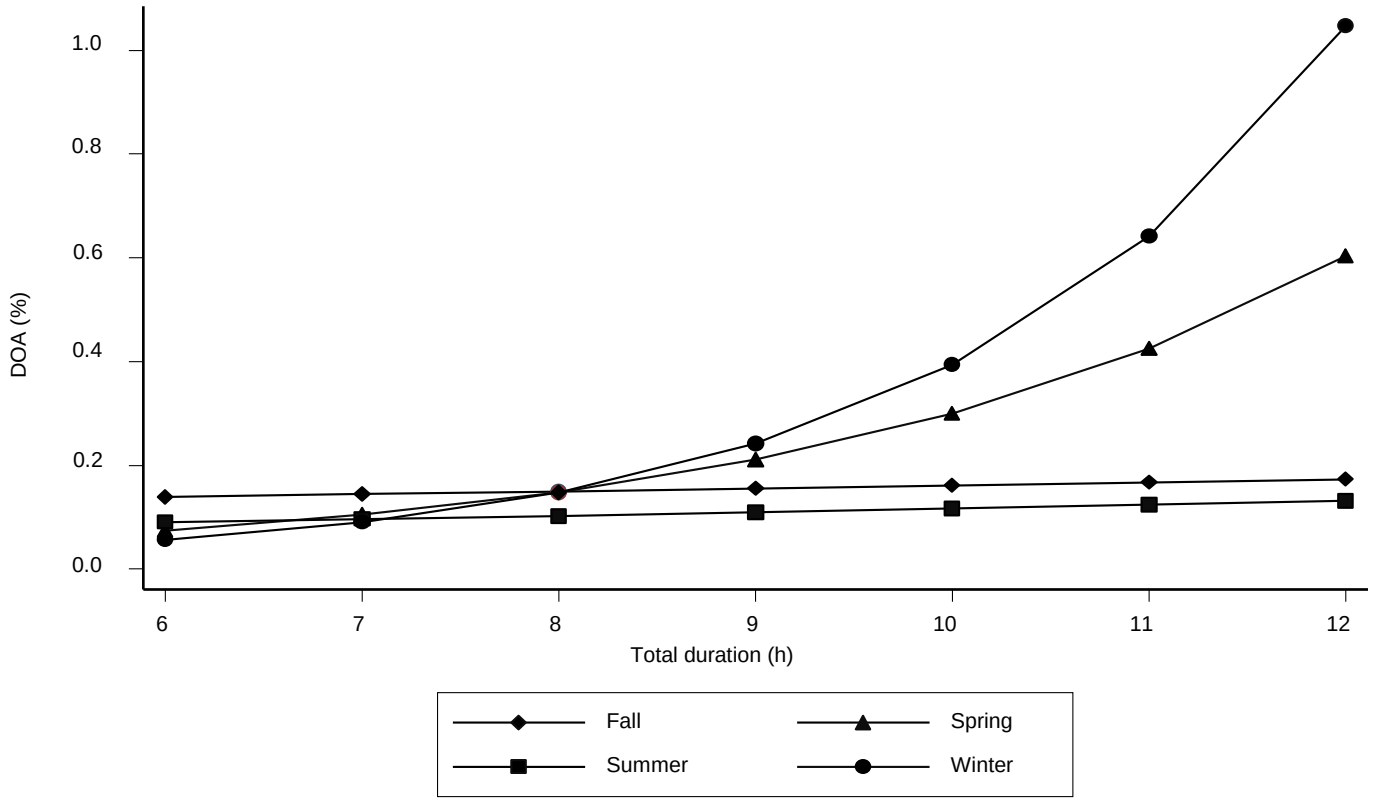
Journey Duration

- Significant effects of both journey duration and lairage/holding barn duration on mortality risk
- The longer the journey, the more opportunity there is for a bird to die
  - (a) from a chronic disease that decreased the ability of the bird to cope with the transport conditions
  - (b) from an injury sustained during catching and loading, or
  - (c) from environmental extremes possibility aggravated by the period without access to food and water.



Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208

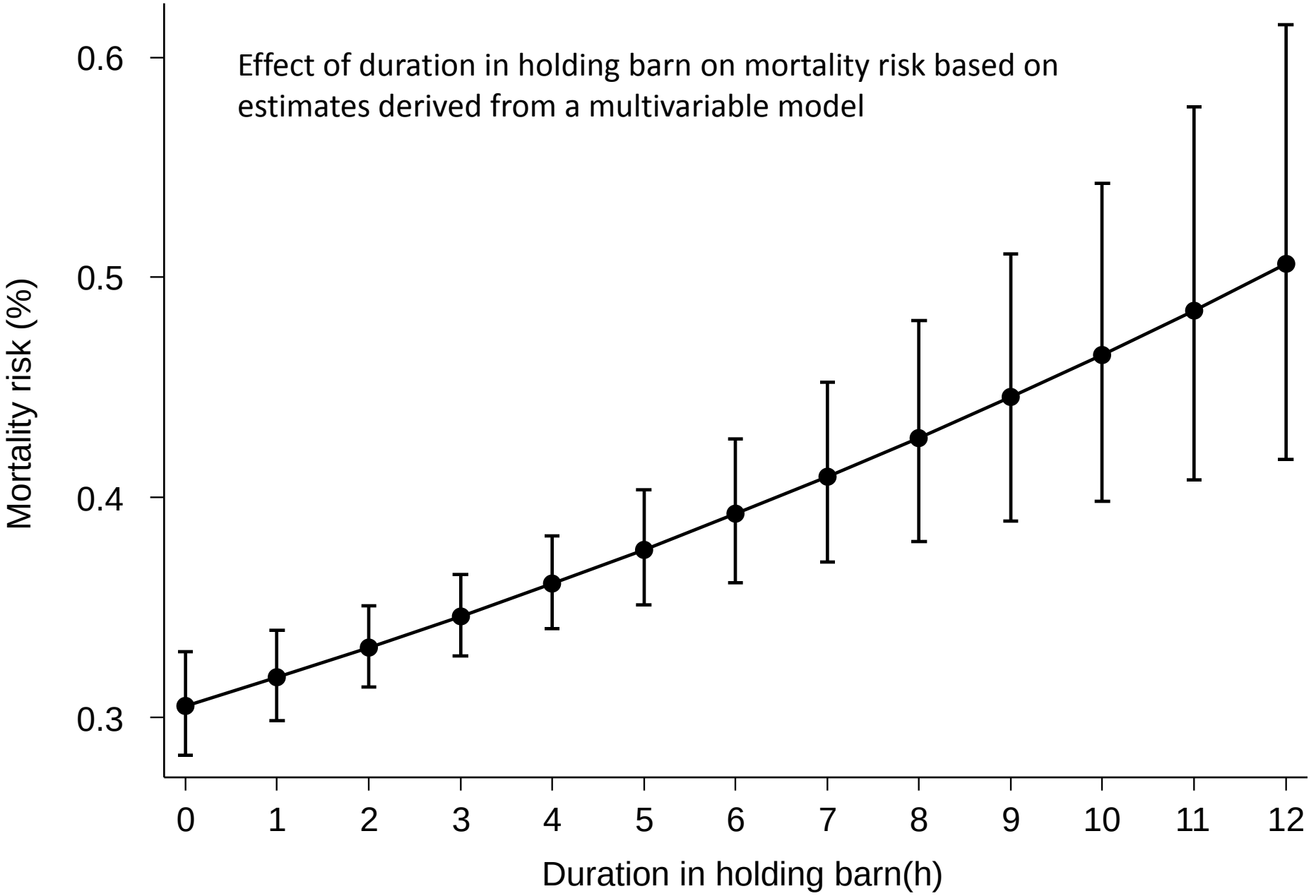
Predictive margins illustrating the effect of total duration from loading until the end of lairage by season on DOA%



Cockram, M.S., Dulal, K.J., Mohamed, R.A. and Revie, C.W. Risk factors for bruising and mortality of broilers during manual handling, module loading, transport and lairage. *Canadian Journal of Animal Science*

Lairage/holding barn Duration

- Although normally not possible to separate mortality that occurs during lairage from that during other stages birds are at risk of dying during the time that they spend in a holding barn
- Some of the deaths during lairage, a delayed consequence of injury during loading and others the result of problems experienced during the journey, e.g. hypothermia or hyperthermia.



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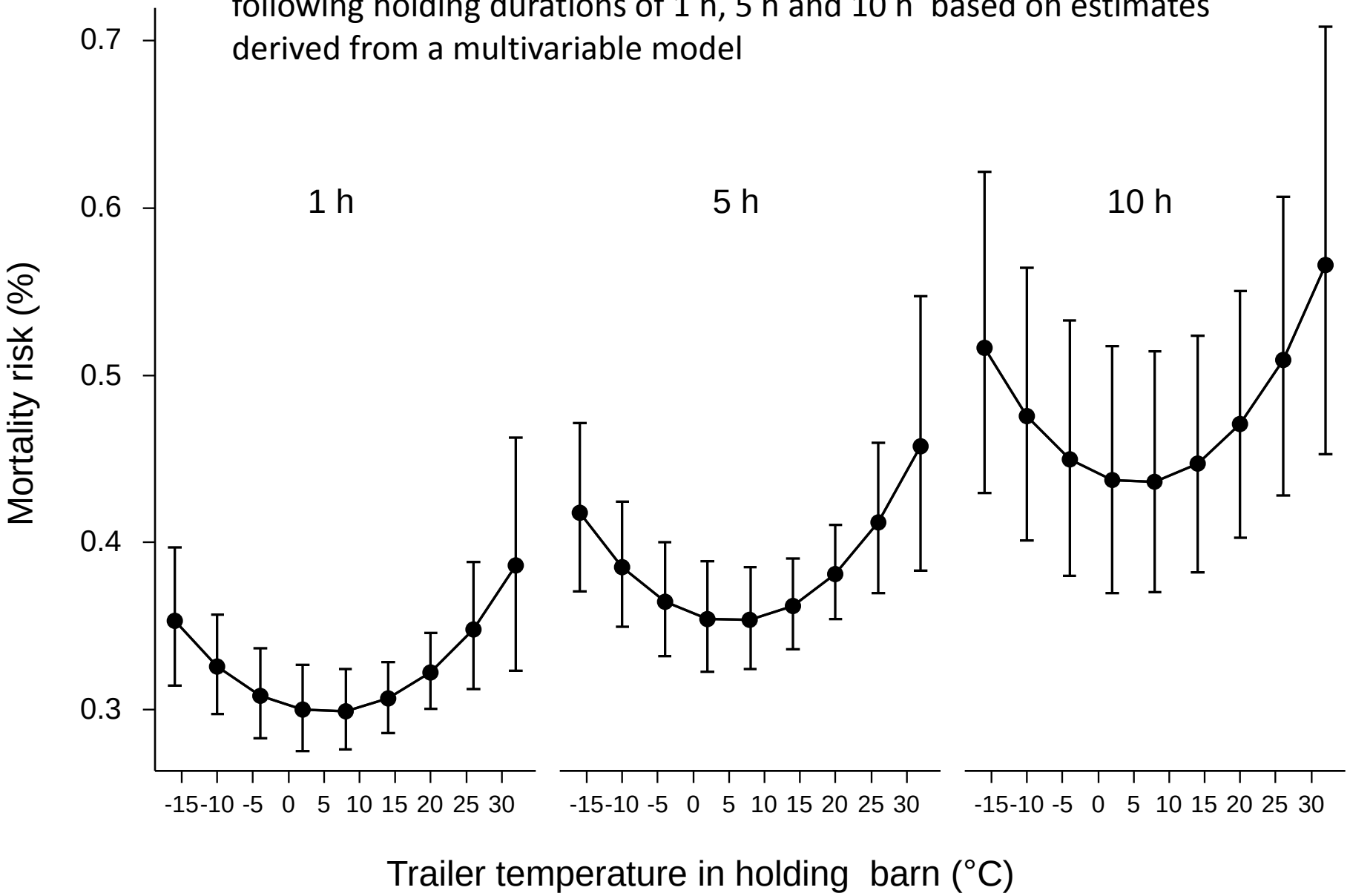
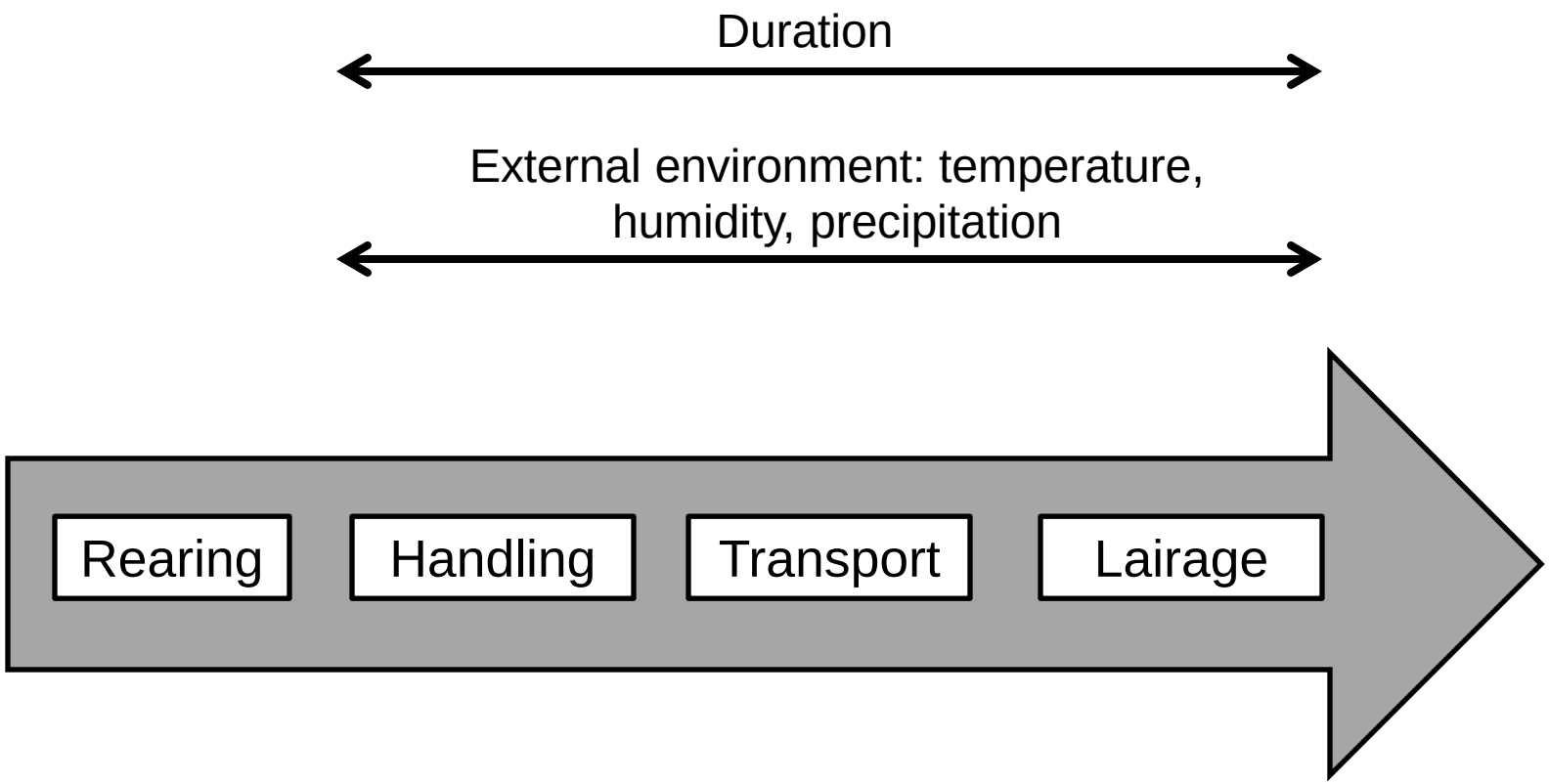


Caffrey, N.P., Dohoo, I.R. and Cockram, M.S. 2017. Factors affecting mortality risk during transportation of broiler chickens for slaughter in Atlantic Canada. *Preventive Veterinary Medicine* 147: 199-208

Summary of risk factors affecting % DOA during each pre-slaughter stage.



Conclusions

- No relationships were found between the manner in which the broilers were handled and the % DOA or % of bruised birds.

To minimise mortality

- Avoid long fasting durations before loading
- Avoid long journey durations especially during winter
- Avoid long waiting times in the holding barn

- Extreme cold conditions can exceed the capacity of some systems of transportation to provide environmental conditions that minimise mortality.