

Effect of transport time up to 8 hours on physiological and biochemical stress indicators and resulting carcass and meat quality in cattle – an integrated approach

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Applied animal welfare at transport and slaughter

- training
- consultancy
- applied science



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**AIM: to evaluate the impact of transport time
within the context of stress factors during transport**

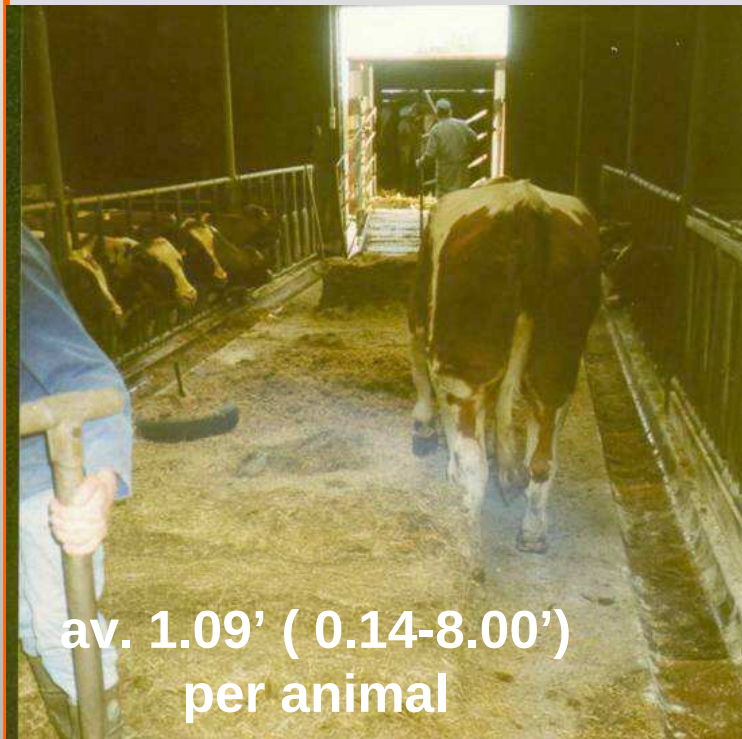
Methods/ Transports/ Animals

- field study between June 2000 and August 2002
- **57** days, **63** commercial transports
- **580 cattle**, i.e. 197 bulls, 238 cows and 145 heifers
- black and red-holstein, but also some dual purpose and meat breeds
- keeping system: groups in stables (76%), tied (13%) and pasture (11 %)

**Field study: “all” possible impacts have to be recorded
and included in the statistical model**

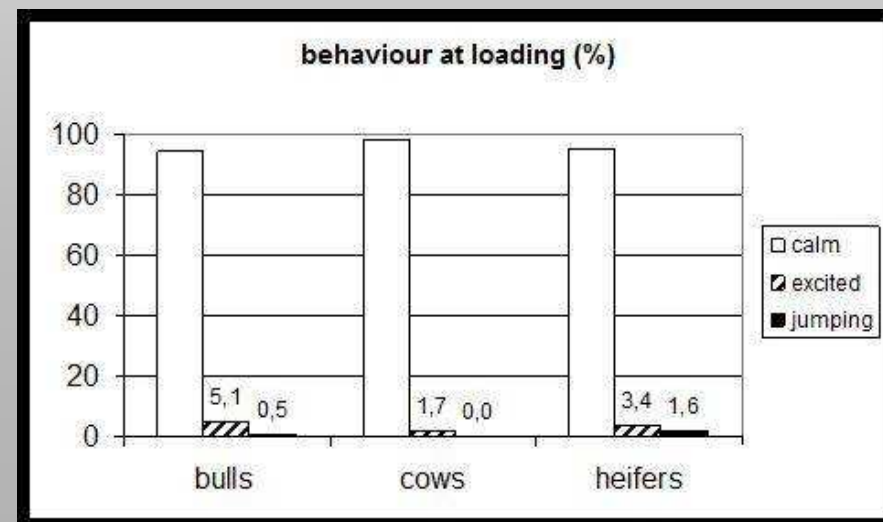
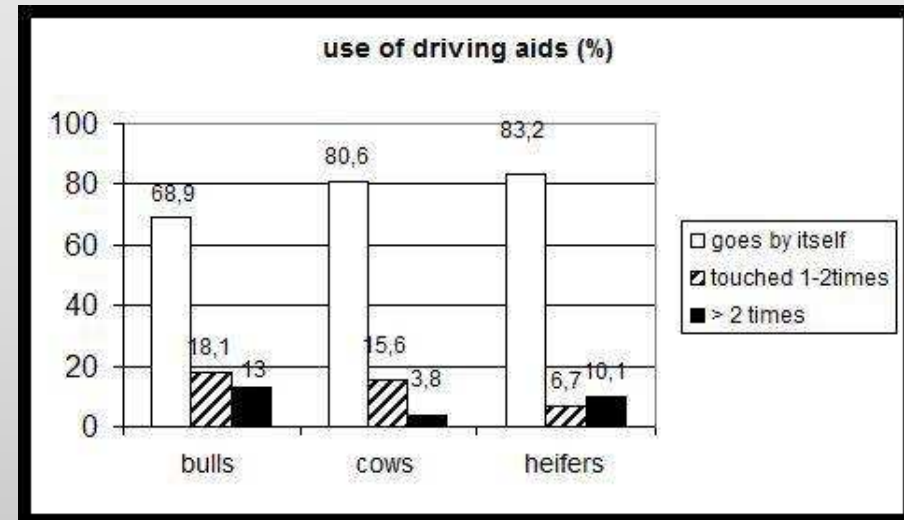
methods ff.

Loading



av. 1.09' (0.14-8.00')
per animal

- use of driving aids
- behaviour at loading
- falling/ lameness/ damages



methods ff.

Vehicles/ Conditions



lorry single decked

- mechanical ventilation
- air springs
- ø lifeweight (B/C/H):
628/ 640/ 594 kg
- ø slaughterweight (B/C/H):
350/ 321/ 312 kg
- loose groups: 3-6 animals
- ø space/animal: 1,6 m²
1,1-3,9 m²
- mixing strange animals: 48%
- mixing sexes: 8.5% of cattle
- mixing horned/hornless: 24%
- bedding sufficient: 72%/not: 28%

methods ff.

Vehicles/ Conditions



road train
single decked

outside

- Av. Temp. ø 9.9 (-4 to 25)°C

- Humidity ø 85 (59 to 99) %

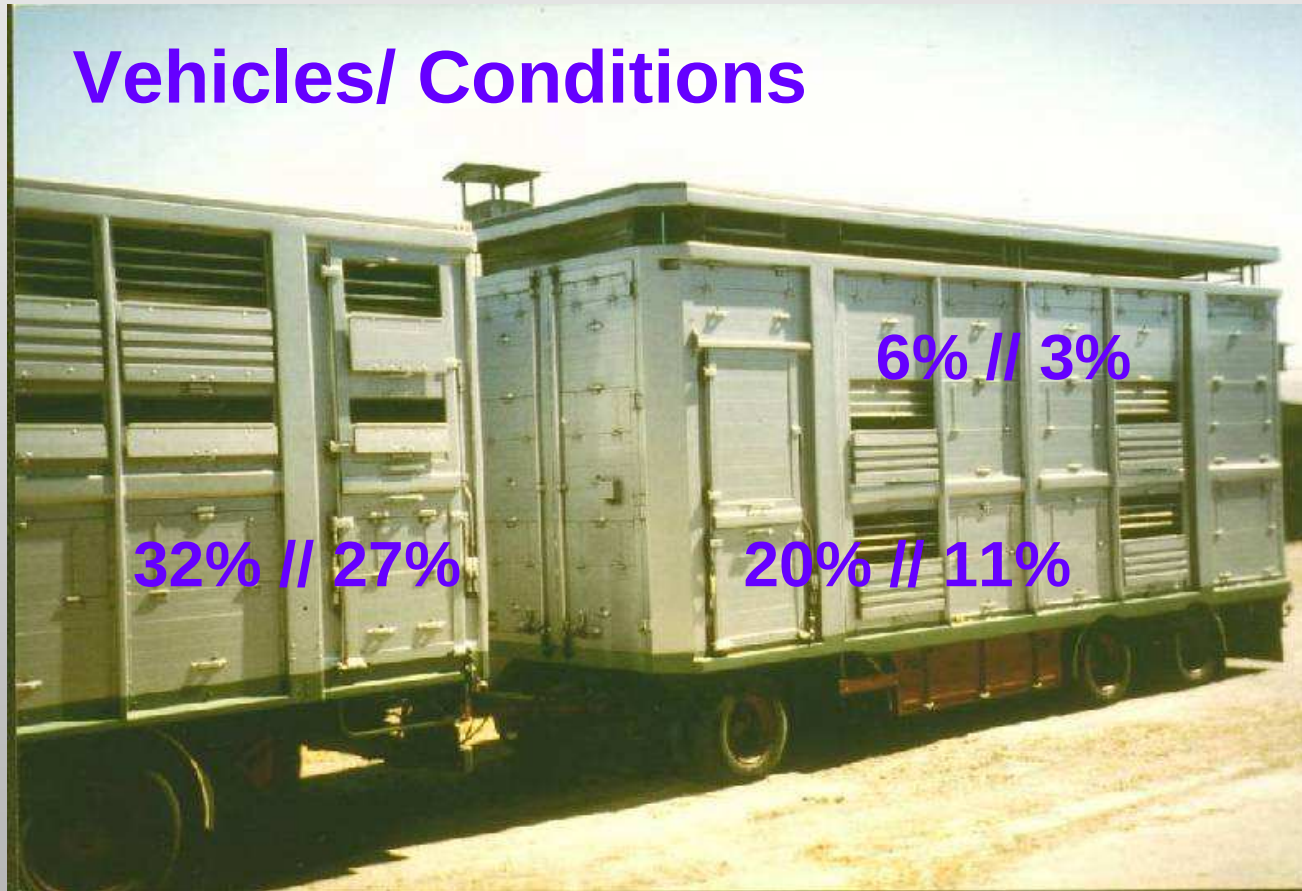
truck

- Av. Temp. ø 13.5 (0 to 27)°C
- Temp. 95% ø 15.8 (5 to 28)°C
- Temp. min ø 11.1 (-1 to 24)°C

- Av Humidity ø 86 (57 to 100) %

methods ff.

Vehicles/ Conditions



- compartment position on the truck
- use of mounting preventions
- reloading

road-train / trailer double decked

methods ff.

Transport - time

- transport time 30 minutes - 8 hours (15-300 km)
- 1-6 (max:10) stops/ stoptime up to 200 minutes

Road Quality Index

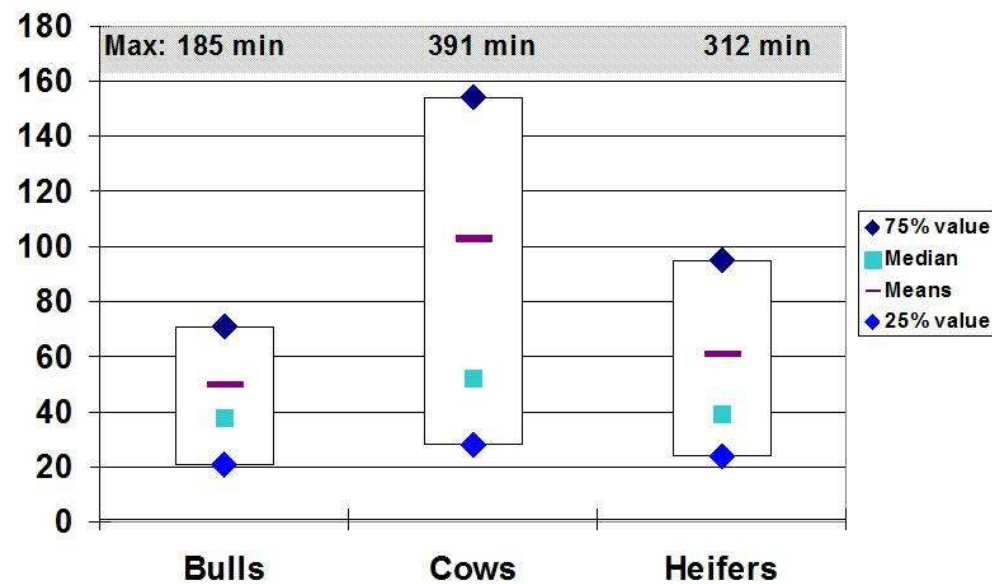
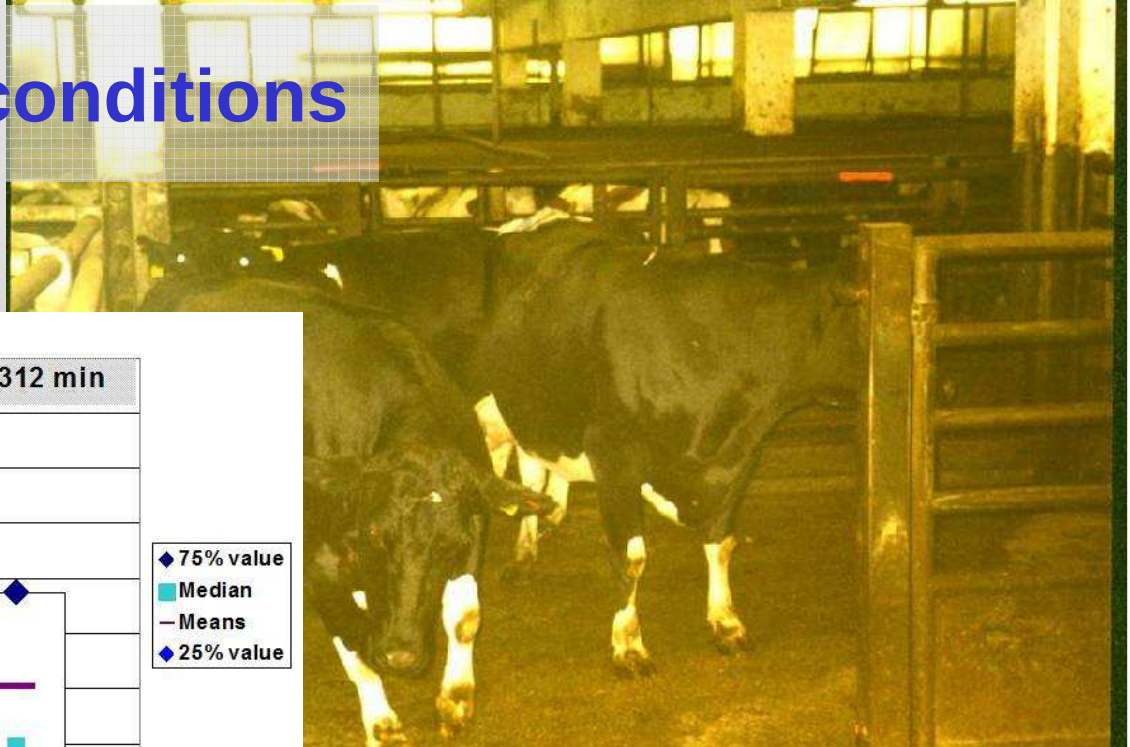
$RQI = 0,01 * \Sigma (\% \text{ real driving time}_{(\text{road-type})} * \text{road-value}_{(\text{road-type})})$



road-value: '1'- highway
'2'- secondary roads
'3'- small roads
'4'- very small roads
(covered, single file)
'6'- dust roads

methods ff.

Lairage time and conditions



Special events during lairage/ driving:

- mounting active or passive,
- fighting or
- excitement in stunning box

methods ff.

Stunning and Bleeding



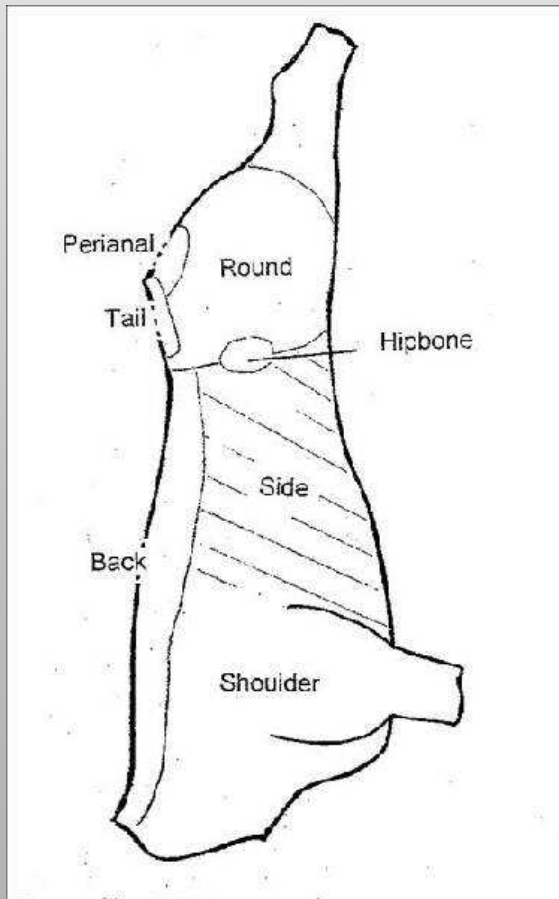
- stunning effectiveness
- excitations after stunning
- pithing (until 1.1.2001)
- electrical immobilisation

- sticking 50s after stunning
- body temp. (captive bolt hole)
- blood sample for
 - CK (Photometry (Cobas/Mira®))
 - Lactate ”
 - Glucose ”
 - NEFA ”
 - β -Hydroxy-Butyrate
 - Cortisol (RIA)



methods ff.

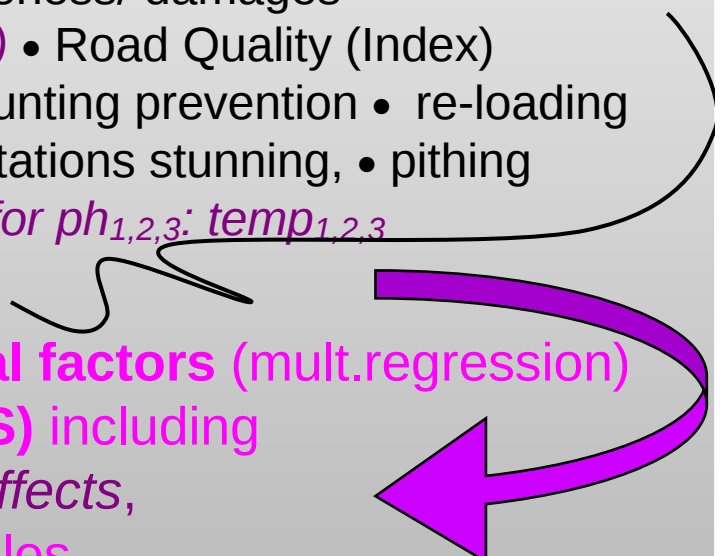
Carcass- and Meat Quality



- bruising related to localisation and intensity (HONKAVAARA, 2000)
- bruising score
 - 0:** no
 - 1:** one slight
 - 2:** more than one slight
 - 3:** one severe
 - 4:** one severe + one or more slight
 - 5:** more than one severe bruise
- Temp₁ / PH₁ : 50 min. p.m.
Temp₂ / PH₂ : 5 h p.m.
Temp₃ / PH₃ : 24 h p.m.

Factors included in integrated model

linear/ gradual factors:

- use of driving aids • excitement at loading • *mixing strange animals*
 - mixing male/female or horned/polled • falling/ lameness/ damages
 - *transport time (i)* • *real driving time* + • *stoptime (ii)* • Road Quality (Index)
 - number of stops • bedding • available space • mounting prevention • re-loading
 - mounting or fighting in lairage • *lairage time* • excitations stunning, • pithing
 - electrical immobilisation • carcass dressing (%) • *for $ph_{1,2,3}$: $temp_{1,2,3}$*
 - Temp/ humidity vehicle, • Temp/ humidity outside
- 

1) Scanning for important independent gradual factors (mult.regression)

2) Multiple analysis of variance (proc glm, SAS) including
a) fixed effects, + b) certain permanent linear effects,
and results of 1) as covariables

fixed effects:

- sex • breed • slaughter house • season of the year • housing (group, tied, pasture)
- unloading (level/slope, back/side) • mounting prevention • bedding
- position on truck • mixing male/female or horned/polled • falling/lame/ damages
- mounting or fighting in lairage • excitations at stunning • pithing
- electrical immobilisation • *transport time classes <2h, 2-4h, 4-6 h, > 6h (iii)*

Results Statistical Analysis:

Body Temperature at Slaughter

- one hour **transport time** ↘ 0.04°C ** (r²=0.43)
 - one hour **stop time** ↘ 0.07 °C** (r²=0.43)
 - one hour lairage time ↘ 0.05°C * (r²=0.52/0.43)
- ↗ bulls, tied cattle, excitement at loading, mounting, fighting, excitement in stunning box
- ↘ mounting prevention, insufficient bedding
- ➔ **Isolated time effect: recreation**
- ➔ **no heat stress, moderate climatic conditions**

↗ = parameter (here body temperature at slaughter) increased by ... , ↘ parameter decreased by ...

results

Cortisol

Real values: pre transport Ø 25 ng/ml, sticking blood Ø 44 ng/ml

Statistical analysis:

- one hour **real driving time** ↗ 3.5 ng/ml * ($r^2=0.40$)
- one hour **stoptime** ↘ 2.2 ng/ml + ($r^2=0.40$)
- one hour **lairage time** ↘ 4.1 ng/ml*** ($r^2=0.43/0.42$)

Cortisol (ng/ml) Is-mean +/- standard error	Classes of transport time ***			
	1: <2 h	2: 2-4 h	3: 4-6 h	4: >6 h
$r^2=0.43$, n= 368 temp vehicle incl.	65.8 ^{2,3,4} +/- 4.7	52.1 ¹ +/- 5.1	57.6 ^{1,4} +/- 5.2	49.5 ^{1,3} +/- 6.2
$r^2=0.42$, n= 580 without temp.veh.	69.0 ^{2,3,4} +/- 5.0	52.2 ¹ +/- 5.1	50.7 ¹ +/- 5.0	43.6 ¹ +/- 6.2

➔ beginning of transport stressful, afterwards adaptation
(same pattern for glucose)

results

CK

Real values: pre transport Ø 142 U/l, sticking blood Ø 224 U/l

Statistical analysis:

- one hour **transport time** ↗ 54 U/l * ($r^2=0.45$)
- one hour **real driving time** ↗ 119 U/l ***($r^2=0.46$)
- one hour **lairage time** ↗ 26 U/l ** ($r^2=0.46$)

CK (U/l) ls-mean +/- standard error	transport time classes**			
	1: <2 h	2: 2-4 h	3: 4-6 h	4: >6 h
$r^2=0.45$, n= 368 temp vehicle incl.	151 ^{2,3,4} +/- 82	290 ^{1,3,4} +/- 88	349 ^{1,2} +/- 82	443 ^{1,2} +/- 98
$r^2=0.37$, n= 580 without temp.veh.	223 ^{2,3,4} +/- 64	370 ^{1,4} +/- 67	384 ^{1,4} +/- 64	476 ^{1,2,3} +/- 78

→ > 6 h transport time: beginning of muscular fatigue

results

NEFA

Real values: pre transport Ø185 µmol/l, post transport Ø266 µmol/l

Statistical analysis:

- one hour **real driving time** ➔ 29 µmol/l ** ($r^2=0.24$)
- one hour **lairage time** ➔ 16 µmol/l *** ($r^2=0.25$)

NEFA (µmol/l) ls-mean +/- standard error	transport time classes***			
	1: <2 h	2: 2-4 h	3: 4-6 h	4: >6 h
$r^2=0.26$, n= 368 temp vehicle incl.	279 ^{2,3,4} +/- 35	368 ¹ +/- 35	408 ^{1,4} +/- 36	355 ^{1,3} +/- 44
$r^2=0.25$, n= 580 without temp. veh.	297 ^{2,3} +/- 33	371 ¹ +/- 36	379 ^{1,4} +/- 34	327 ³ +/- 43

➔ >4h: slight tendency towards catabolic metabolism
not relevant, but: additional effect lairage time !

➔ no ketotic situation: β-Hydroxy-butyrate < 0,4 mmol/l

results

Bruising

“Real” bruising score (0-5) Ø 1.0 post transport

Statistical analysis:

- one hour **real driving time** ↗ 0,38 ** ($r^2=0.33$)

Bruising score ls-mean +/- standard error	transport time classes ***			
	1: <2 h	2: 2-4 h	3: 4-6 h	4: >6 h
$r^2=0.37$, n= 368 temp vehicle incl.	1.45 ⁴ +/- 0.41	1.63 ^{3,4} +/- 0.43	1.12 ^{2,4} +/- 0.43	2.83 ^{1,2,3} +/- 0.51
$r^2=0.29$, n= 580 without temp. veh.	0.65 ⁴ +/- 0.30	1.05 ⁴ +/- 0.30	0.74 ⁴ +/- 0.30	1.64 ^{1,2,3} +/- 0.36

➔ marked increase of bruising for transport times > 6h

results

Examples for Carcass Bruising



slight



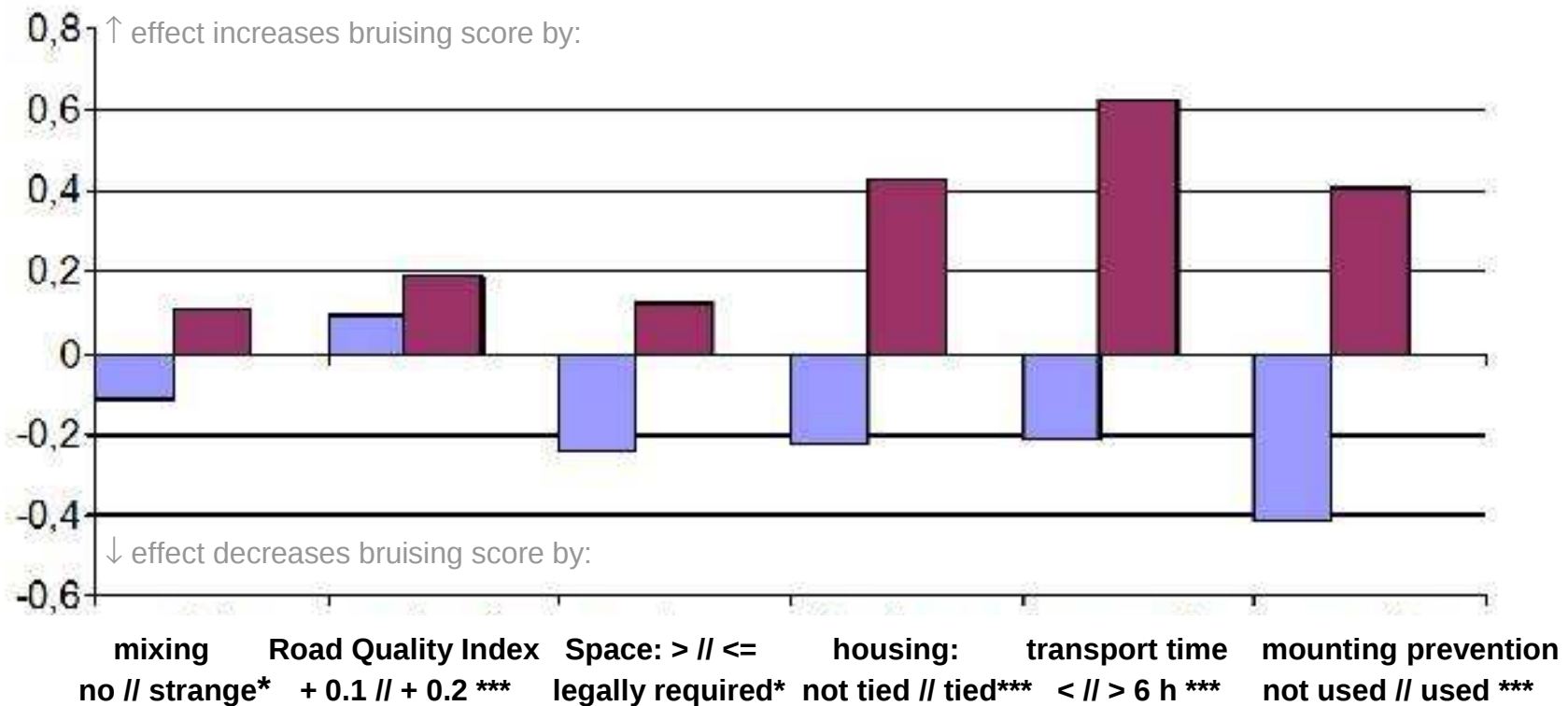
severe



6% of the bulls had severe bruising (back, tail, hip), cows 25%, heifers 15%

results

Significant Effects on Carcass Bruising Score



(mounting prevention was often set too low)

German order welfare at transport: live weight up to 500/ 550 / 600 / 650 / 700 / >700 kg:
minimum space per animal: 1.35/ 1.40/ 1.47/ 1.53/ 1.60/ 2.00 m²

results

pH24

Statistical analysis:

- one hour **transport time** ↗ 0.03 * ($r^2=0.21$)
- ↗ summer, bulls, milkbreeds, tied cattle, mixing strange cattle, mixing sexes (pH5)
- ↘ more space than legally required, use of mounting prevention (pH5)
insufficient bedding

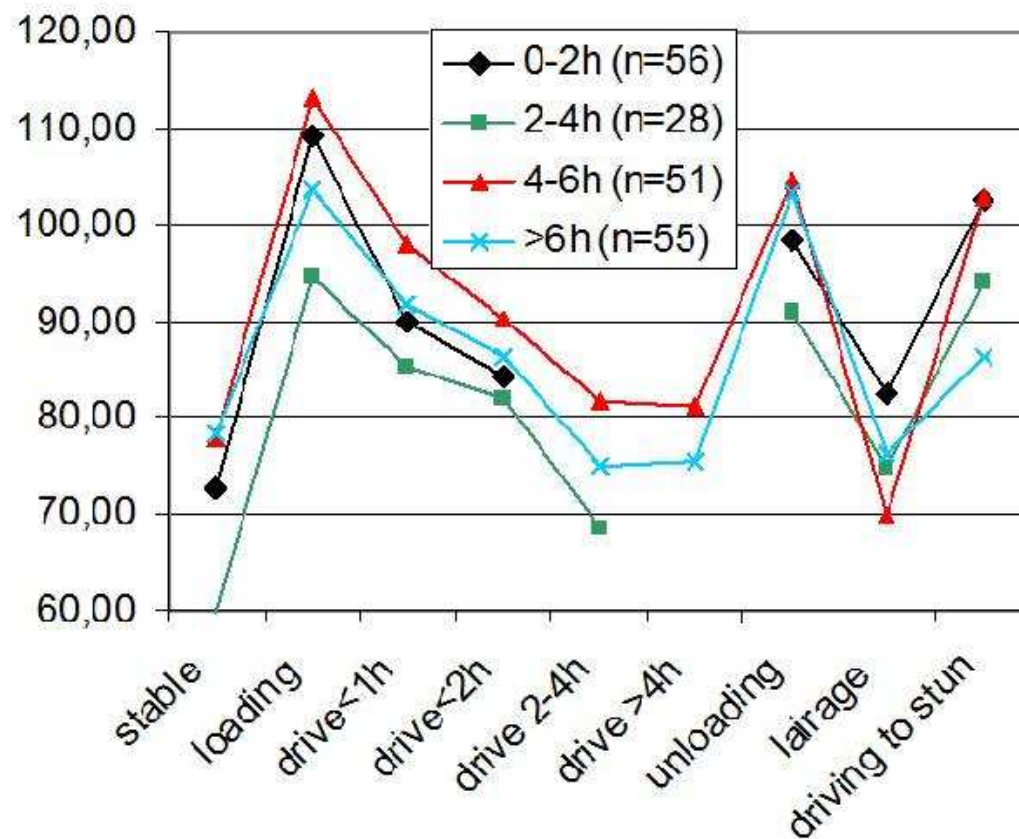
PH24) ls-mean +/- standard error $r^2=0.27$, n= 368 temp. vehicle incl.	transport time classes*			
	1: <2 h	2: 2-4 h	3: 4-6 h	4: >6 h
	5.52 ^{2,3,4} +/- 0.06	5.62 ^{1,4} +/- 0.07	5.62 ^{1,4} +/- 0.07	5.72 ^{1,2,3} +/- 0.08

➔ increase of pH 24 for transports > 6h

results

„Real“ Heart Rate

means over different time sections by time groups



➔ single animals with elevated heart rate (> 4-6h)

➤ summer, heifers, excitement at loading, road quality index, mixing strange cattle

Conclusions / Discussion

- **General:** Transport comprehends many risks (adverse effects), to estimate the impact of only one of them (here: transport time) needs complex models and many animals
- Different impact of **transport time**, **stoptime**, **real driving time**
- **Isolated time effects** (transports < 8 hours, German slaughter cattle):

Linear: ↗ **CK, NEFA, pH24, bruising, cortisol, HRL**
(muscle work, energy demand and quality decrease)
↘ **body temp, cortisol (some adaption)**

Classified !↗!(>6h): CK, (NEFA), bruising score, pH24
(muscular fatigue and quality loss > 6 h)

- ☒ calm down after start of transport (within first 2 hours)
- ☒ transport time limit of 6 h would be advantageous with regard to welfare and quality
- **Other risks beside time:** mixing, mounting, overloading, insufficient space, tied housing, bad roads, impaired fitness



Many thanks to transport companies,
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and slaughtermen,
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Thank You very much !