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

Dr. Karen von Holleben
(info@bsi-schwarzenbek.de)
Training and consultancy institute for careful handling of breeding and slaughter animals (bsi schwarzenbek)

Applied animal welfare at transport and slaughter
• training
• consultancy
• applied science
Effect of transport time up to 8h on physiological and biochemical stress indicators and resulting carcass / meat quality in cattle

Dr. Karen v. Holleben
Training and consultancy institute for careful handling of breeding and slaughter animals (bsi), Schwarzenbek, Germany

Dr. Thomas Schmidt
Consulting Company for Animal Husbandry and Biometrics Neustadt-Mariensee, Germany

Dr. Sandra Henke, Martina Hohmann
Prof. Jörg Hartung
Institute of Animal Hygiene, Animal Welfare and Behaviour of Farm Animals, School of Veterinary Medicine Hanover, Germany

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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
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Loading

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

av. 1.09’ (0.14-8.00’) per animal
Vehicles/ Conditions

- 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%
Vehicles/ Conditions

outside
- Av. Temp. $\bar{\theta}$ 9.9 (-4 to 25)$^\circ$C
- Humidity $\bar{\theta}$ 85 (59 to 99) %

truck
- Av. Temp. $\bar{\theta}$ 13.5 (0 to 27)$^\circ$C
- Temp. 95% $\bar{\theta}$ 15.8 (5 to 28)$^\circ$C
- Temp. min $\bar{\theta}$ 11.1 (-1 to 24)$^\circ$C
- Av Humidity $\bar{\theta}$ 86 (57 to 100) %
Effect of transport time up to 8h on physiological and biochemical stress indicators and resulting carcass / meat quality in cattle

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

Vehicles/ Conditions

road-train / trailer double decked

6% // 3%
32% // 27%
20% // 11%
Transport - time

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

Road Quality Index

\[ RQI = 0.01 \sum \% \text{real driving time}(\text{road-type}) \times \text{road-value}(\text{road-type}) \]

road-value:
- ‘1‘- highway
- ‘2‘- secondary roads
- ‘3‘- small roads
- ‘4‘- very small roads (covered, single file)
- ‘6‘- dust roads
Lairage time and conditions

Special events during lairage/ driving:
- mounting active or passive,
- fighting or
- excitement in stunning box
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Stunning and Bleeding

- 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.

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

- Temp$_1$ / PH$_1$ : 50 min. p.m.
- Temp$_2$ / PH$_2$ : 5 h p.m.
- Temp$_3$ / PH$_3$ : 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 ph1,2,3: *temp1,2,3*
- 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** \(\downarrow\) 0.04°C ** (\(r^2=0.43\))
- one hour **stoptime** \(\downarrow\) 0.07 °C** (\(r^2=0.43\))
- one hour **lairage time** \(\downarrow\) 0.05°C * (\(r^2=0.52/0.43\))

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

\(\uparrow\) = parameter (here body temperature at slaughter) increased by … , \(\downarrow\) parameter decreased by …
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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 **stop time** ➖ 2.2 ng/ml + \( (r^2=0.40) \)
- one hour **lairage time** ➖ 4.1 ng/ml*** \( (r^2=0.43/0.42) \)

<table>
<thead>
<tr>
<th>Cortisol (ng/ml)</th>
<th>Classes of transport time ***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1: &lt;2 h</td>
</tr>
<tr>
<td><strong>Is-mean</strong></td>
<td></td>
</tr>
<tr>
<td>+/- standard error</td>
<td></td>
</tr>
<tr>
<td>r²=0.43, n= 368 temp vehicle incl.</td>
<td>65.8(^{2,3,4})</td>
</tr>
<tr>
<td>+/- 4.7</td>
<td>+/- 5.1</td>
</tr>
<tr>
<td>r²=0.42, n= 580 without temp.veh.</td>
<td>69.0(^{2,3,4})</td>
</tr>
<tr>
<td>+/- 5.0</td>
<td>+/- 5.1</td>
</tr>
</tbody>
</table>

⇒ beginning of transport stressful, afterwards adaptation (same pattern for glucose)
**CK**

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

Statistical analysis:

- one hour transport time ➤ 54 U/l * (r²=0.45)
- one hour real driving time ➤ 119 U/l ***(r²=0.46)
- one hour lairage time ➤ 26 U/l ** (r²=0.46)

<table>
<thead>
<tr>
<th>CK (U/l) ls-mean +/- standard error</th>
<th>1: &lt;2 h</th>
<th>2: 2-4 h</th>
<th>3: 4-6 h</th>
<th>4: &gt;6 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>r²=0.45, n= 368 temp vehicle incl.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r²=0.37, n= 580 without temp.veh.</td>
<td>151²,³,⁴ +/- 82</td>
<td>290¹,³,⁴ +/- 88</td>
<td>349¹,² +/- 82</td>
<td>443¹,² +/- 98</td>
</tr>
<tr>
<td></td>
<td>223²,³,⁴ +/- 64</td>
<td>370¹,⁴ +/- 67</td>
<td>384¹,⁴ +/- 64</td>
<td>476¹,²,³ +/- 78</td>
</tr>
</tbody>
</table>

➤ > 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 *** ($r^2=0.25$)

<table>
<thead>
<tr>
<th>NEFA (µmol/l) is-mean ± standard error</th>
<th>transport time classes***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1: &lt;2 h</td>
</tr>
<tr>
<td>r²=0.26, n=368 temp vehicle incl.</td>
<td>279²,3,4 ±35</td>
</tr>
<tr>
<td>r²=0.25, n=580 without temp. veh.</td>
<td>297²,3 ±33</td>
</tr>
</tbody>
</table>

>4h: slight tendency towards catabolic metabolism
not relevant, but: additional effect lairage time!
no ketotic situation: β-Hydroxy-butyrate < 0.4 mmol/l
Bruising

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

Statistical analysis:
• one hour real driving time ➔ 0.38 ** (r²=0.33)

| Bruising score | transport time classes **
|----------------|-------------------------
| Is-mean +/- standard error | 1: <2 h | 2: 2-4 h | 3: 4-6 h | 4: >6 h |
| r²=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 |
| r²=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

6% of the bulls had severe bruisings (back, tail, hip), cows 25%, heifers 15%
Significant Effects on Carcass Bruising Score

- Effect increases bruising score by:
  - Mixing: +0.1 // +0.2 ***
  - Road Quality Index: no // strange*
  - Space: > // <=
  - Housing: legally required* // not tied // tied***
  - Transport time: < // > 6 h ***
  - Mounting prevention: not used // used ***

- Effect decreases bruising score by:
  - 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

(mounting prevention was often set too low)
pH24

Statistical analysis:

- One hour transport time $\uparrow 0.03 \,* \,(r^2=0.21)$
- Summer, bulls, milkbreeds, tied cattle, mixing strange cattle, mixing sexes (pH5)
- More space than legally required, use of mounting prevention (pH5)
- Insufficient bedding

<table>
<thead>
<tr>
<th>Transport time classes*</th>
<th>pH24 (is-mean +/- standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: &lt;2 h</td>
<td>$5.52^{2,3,4}$ +/- 0.06</td>
</tr>
<tr>
<td>2: 2-4 h</td>
<td>$5.62^{1,4}$ +/- 0.07</td>
</tr>
<tr>
<td>3: 4-6 h</td>
<td>$5.62^{1,4}$ +/- 0.07</td>
</tr>
<tr>
<td>4: &gt;6 h</td>
<td>$5.72^{1,2,3}$ +/- 0.08</td>
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</tbody>
</table>

⇒ Increase of pH24 for transports > 6h
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„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):

<table>
<thead>
<tr>
<th>Linear:</th>
<th>^ CK, NEFA, pH24, bruising, cortisol, HRL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(muscle work, energy demand and quality decrease)</td>
</tr>
<tr>
<td>✏️️</td>
<td>body temp, cortisol (some adaption)</td>
</tr>
<tr>
<td>Classified !^ !(&gt;6h):</td>
<td>CK, (NEFA), bruising score, pH24</td>
</tr>
<tr>
<td></td>
<td>(muscular fatigue and quality loss &gt; 6 h)</td>
</tr>
</tbody>
</table>

☑ 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, dealers, farmers, drivers, colleagues and slaughtermen, and acknowledgements to EU-funding!

Thank You very much!