Exposure times and stunning effectiveness for argon and nitrogen-argon mixtures for pigs at slaughter

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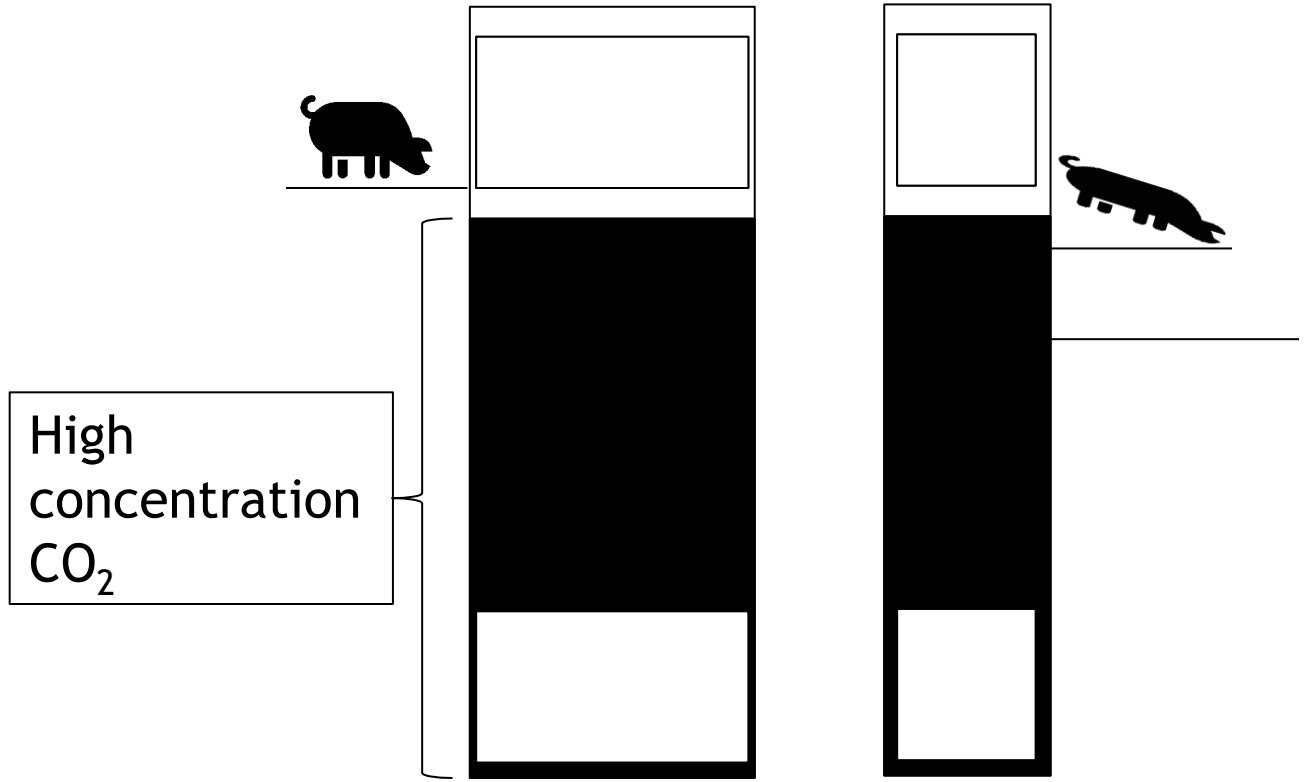
Background: Dip-Lift-System

Dip-Lift System

- A small group of pigs (2-6) entering mobile crate (**gondola**)
- Pit filled with **high concentration CO_2**
- Gondola moves down, exposing pigs to gas atmosphere
- **Dwell time**: time at bottom position
- Gondola moves back up and ejects the animals



Background: Project Tiger

Testing Inert Gases in order to Establish Replacements for high concentration CO2 stunning for pigs at the time of slaughter

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Federal Ministry of Food and Agriculture

Project manager

Federal Office for Agriculture and Food

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QS-Wissenschaftsfonds

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Project partners:

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

Air Liquide

Vion FOOD GROUP

Background — High concentration CO_2 stunning

Benefits

- ✓ Deep and **long lasting unconsciousness** and insensibility
  (Forslid, 1987)
- ✓ **Good meat quality**

Drawback

- **Pigs** can **detect CO_2** at concentrations of about **30%** (EFSA, 2004)
- **Hyperventilation and breathlessness** before loss of consciousness
  (Troeger, 2008; Gregory et al., 1990)
- Irritations of mucus membranes through creation of carbonic acid
  (Peppel und Anton, 1993)
- **Aversive reactions** of animals exposed to CO_2 (e.g. escape attempts)
  (Llonch et al., 2012a,b; Dalmau et al., 2010; Rodriguez et al., 2008; EFSA, 2004; Machold et al., 2003b; Raj und Gregory, 1996)

Background — Inert gases (N_2 and Ar) as alternatives

Inert gas mixtures proposed as an alternative to high concentration CO_2 stunning:

Benefits – pros

- ✓ **Less aversive**

Drawback – cons

- N_2 gas mixtures **less stable** (Dalmau et al., 2010)
- **reduced meat quality** (Llonch et al., 2012 b , Atkinson et al., 2020)
- **Longer exposure times** — more inadequate stuns
  (Machold et al., 2003a; Machold et al., 2003b; Llonch et al., 2012 b, Atkinson et al., 2020)

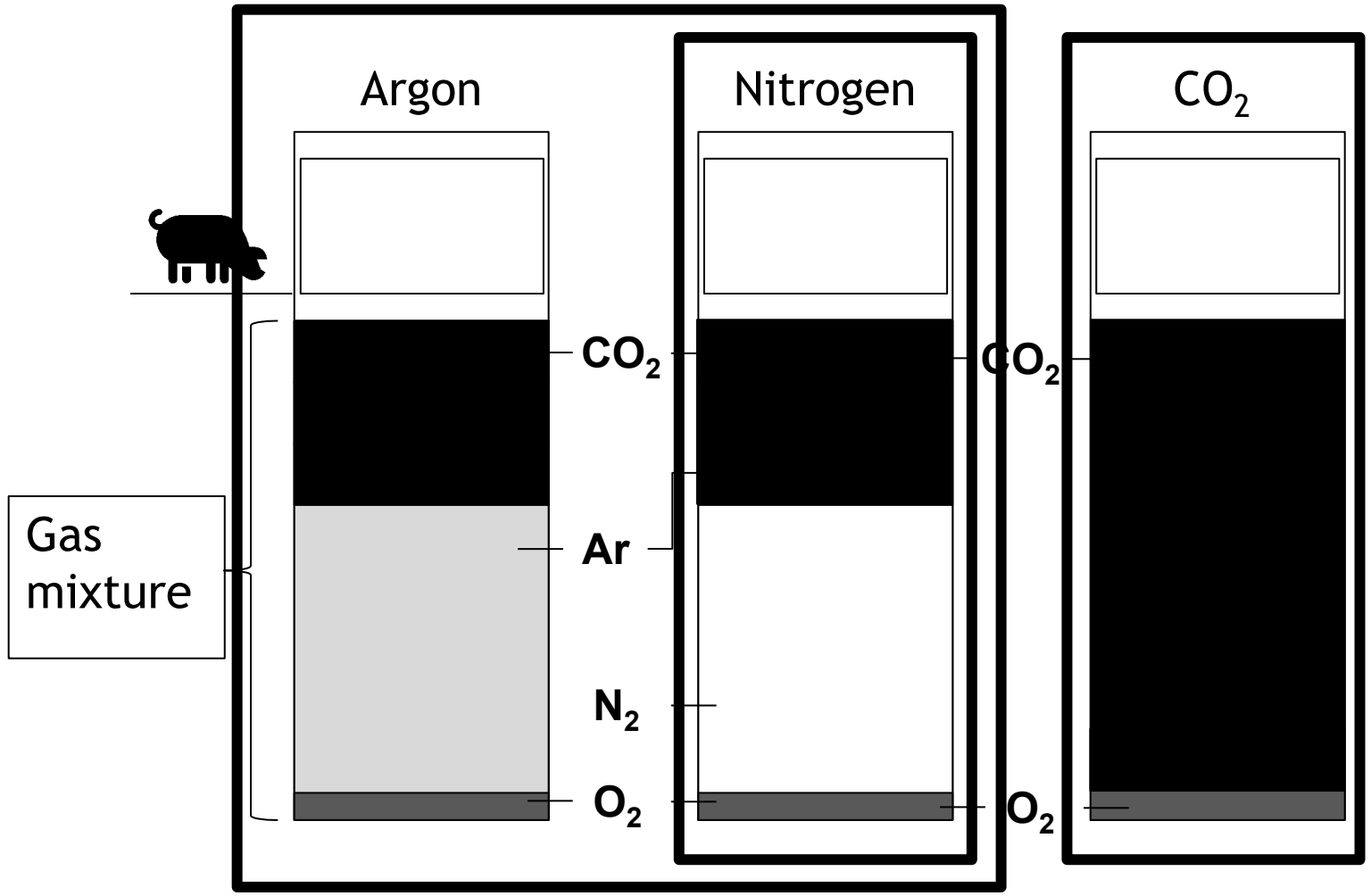
Importance of residual oxygen:

Atkinson et al., 2020		
Residual O_2	< 2 %	> 2 %
Inadequately stunned	5 %	19 %

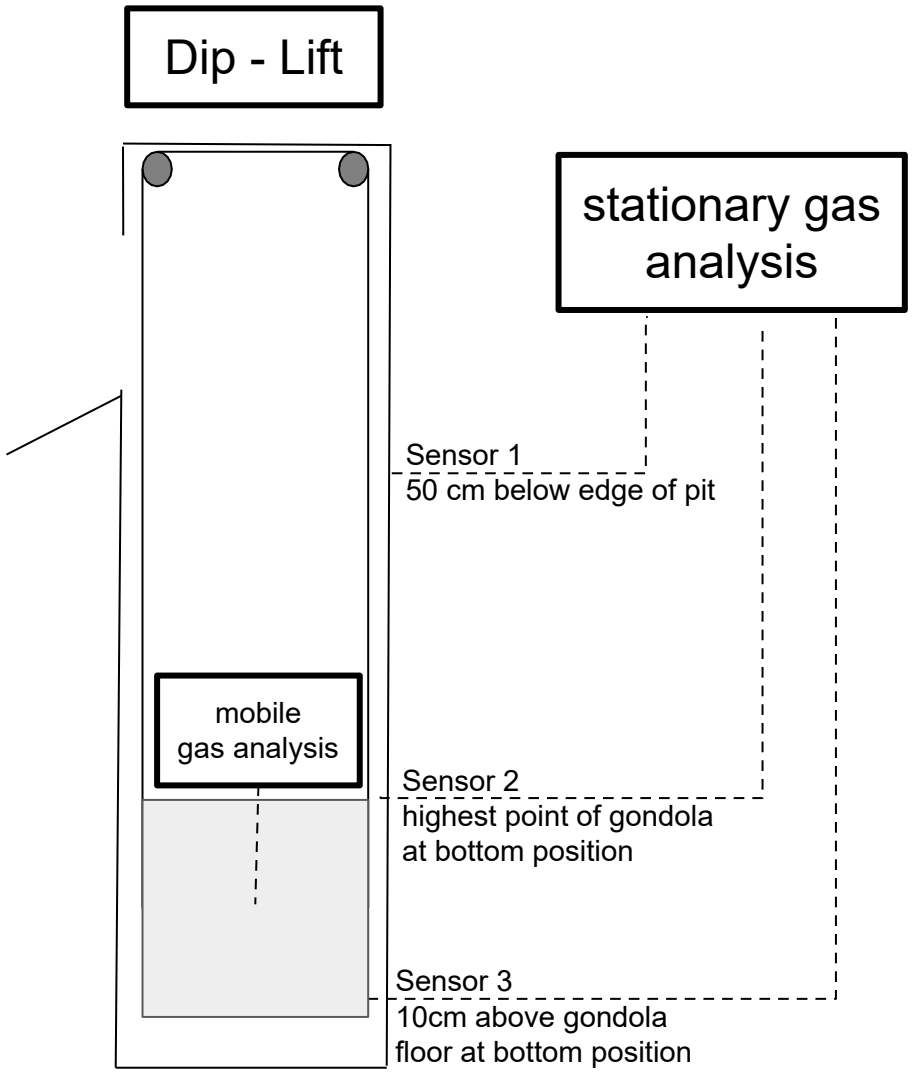
Project goal I

- Find gas mixture best suited to replace high concentration CO_2 stunning
  - **Argon** or **nitrogen** as primary gas
  - residual **oxygen** level: **< 1 %**
  - **CO_2** from **0** to **30 %**

- **90** and **95% CO_2** **control conditions**



Project goal II



- **New** (patented) **gassing system** installed into a commercial Dip-Lift-System
- Gas analyzer to **measure** (CO_2 **and** O_2) and control the gas atmosphere

✓Stable gas atmospheres

✓Residual O_2 well below 1 %

(MDE 3300, htk Hamburg)

Project goal III

- Compare each to high concentration CO_2 based on
  - **aversiveness**
  - **meat quality**
- Determine **necessary dwell times**

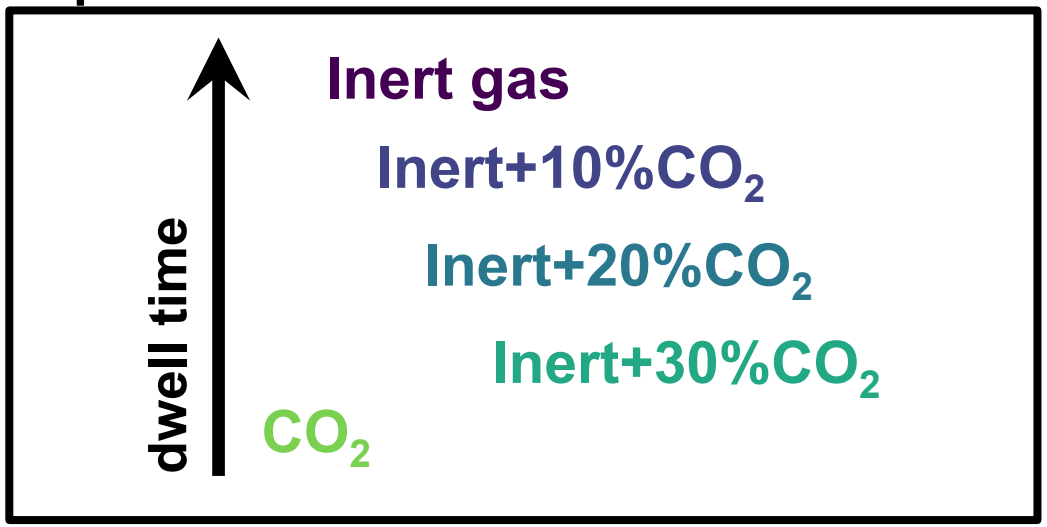
  to accomplish **< 0.5 % inadequate stuns**

Presentation on Thursday in Gratte Ciel 3 at 9:15 (Session 80)

Presented today by Julia Gelhausen

This presentation!

Expectation



Experimental Design: Optimizing exposure time

Selection phase:

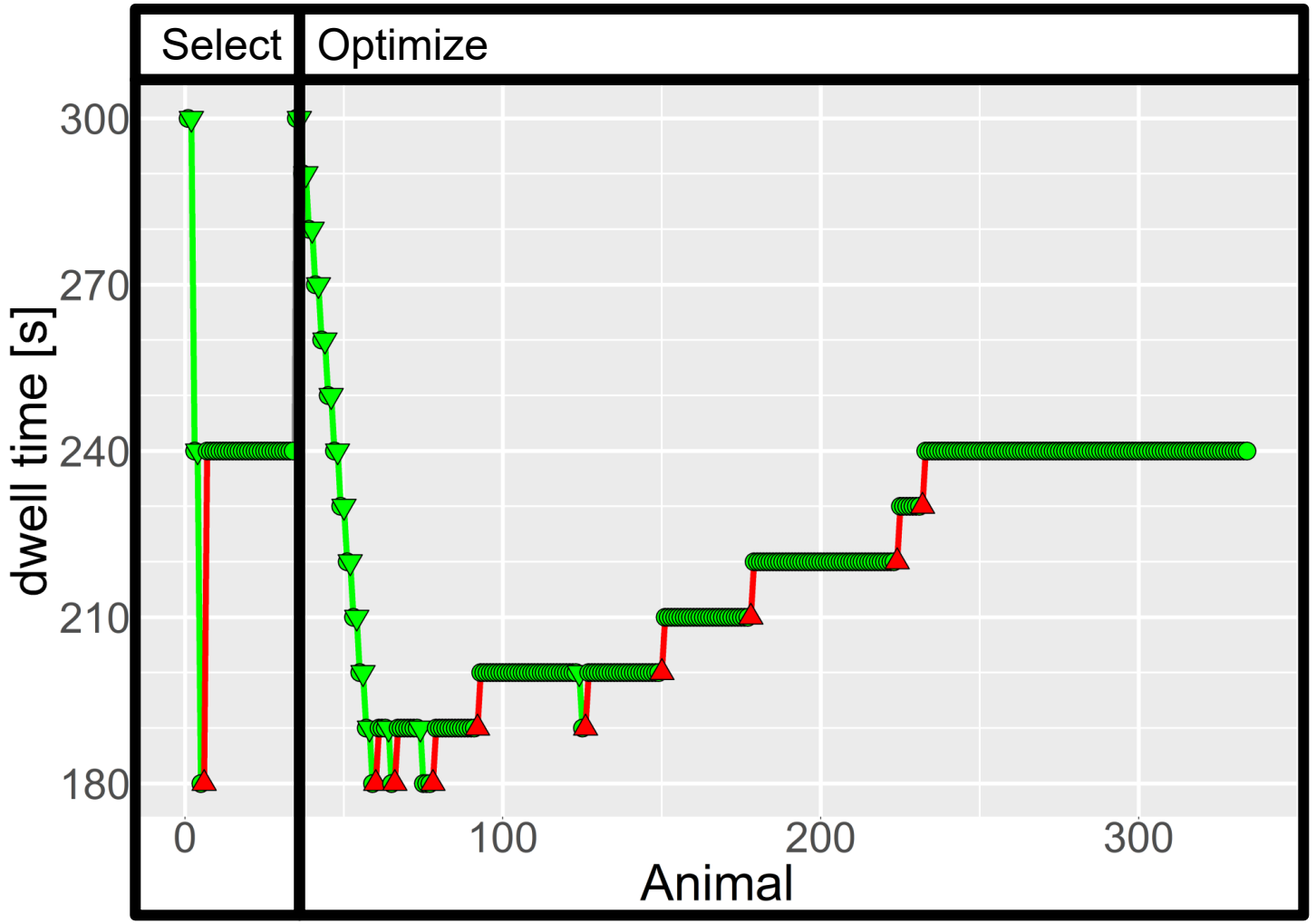
- All 8 gas mixtures
- Optimization in 60 s steps

Optimization phase

- 2 gas mixtures
- **Adapative staircase in 10 s steps**

Analysis

- Logistic regression
- Predict dwell time to achieve inadequate stun rate < 0.5 %



Experimental Design: Stun quality assessment

- 2 pigs per gondola
- 2 observers (one for each pig)
  - Gasping/breathing, coordinated (eye) movements, righting attempts, blinking
  - Reflexes or response to pain stimuli (palpebral, corneal, pupillary reflex, nasal septum, flexor)

©EURCAW-Pigs

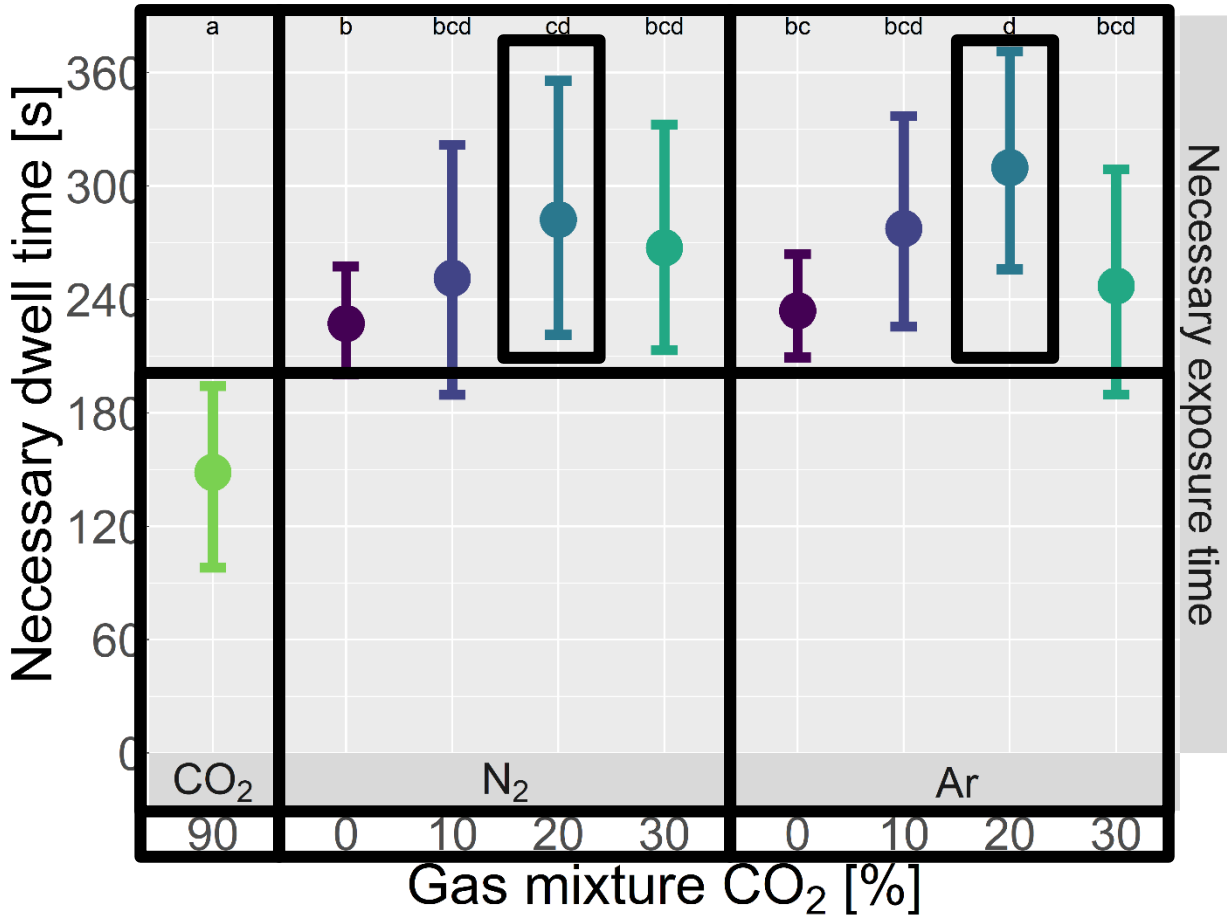
- **Inadequate stun**
  - Defined as:
    - **5 gasps** + **positive reflex twice** OR
    - **coordinated** (eye) **movements**, etc.
  - Waiting for clear signs of likely recovery
  - Swift re-stunning once determined

©Welfare Quality

Results: Necessary exposure time

Necessary dwell time
for 0.5 % inadequate stuns

- Longer for inert gas (mixtures) than CO_2
- **Longest for gas mixtures with 20 % CO_2**



For statistics: glm binomial/logit model

DwellTime*O_2+MainGas+**CO_2**+Series

Results: Indicators for recovery I

- Definition of inadequate stuns
  - 5 gasps + positive reflex twice OR
  - coordinated movements / righting attempts

- **Gasping rarely present when adequately stunned**

Predictability for inadequate stun:

=>obvious signs likely a sufficient indicator alone for inadequate stuns

Inert gas without CO_2

# Obvious Indicators		0	1	4
Predictability		3.4 %	**82 %**	**96 %**
animals	total	676	28	24
	inadequate	23	23	23
	adequate	653	5	1

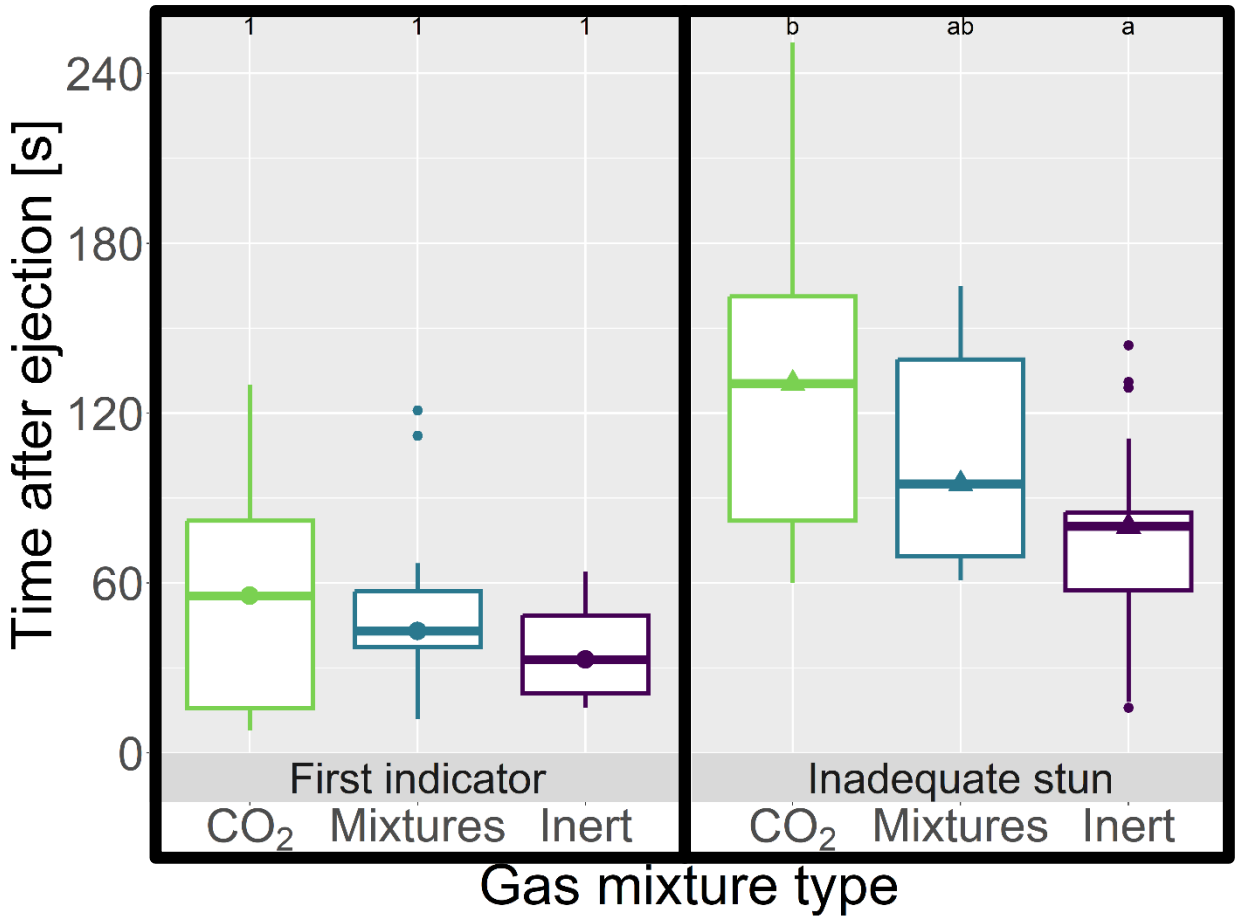
Results: Indicators for recovery II

Time to first indicator of recovery

- appears to occur earlier and in shorter range for inert gases than CO_2
- sometimes very late (>120 s) for CO_2
- No significance, but small N

Time until inadequately stunned

- Earlier for inert gases
- Shorter time span for inert gases



Summary and outlook

- Gassing system allowed **residual oxygen of << 1 %**
- **Necessary exposure time** for 0.5 % inadequate stuns
  - **50 % longer for inert** than for CO_2
  - **No benefit of adding CO_2 to inert gas mixtures**
  - **Longest for** gas mixtures **with 20 % CO_2**
- **Indicators of recovery** for stunning with inert gasses
  - Similar to CO_2 but potentially more predictive and earlier
  - Fast action needed when indicators detected
  - Critical time window likely shorter (easier to monitor)

Thank you!

Next Steps:

- Verifying results in a commercial Paternoster-System
- Is there an influence of number of animals per gondola?