Physiological aspects of stress and welfare

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EAAP 2012 „Session 48“
30. August 2012, Bratislava
• Introduction to concepts
• Tools & indices
  – Stress metabolites
  – Heart & respiration rate
  – Health monitoring & pain
• Conclusions & outlook
Animal welfare

- Physical & psychological well-being of animals
- Human concern for animal welfare > legislation

Main components:
• biological functioning (growth performance, health & reproduction)
• affective states (suffering, pain, emotions)
• expression of „normal“ species-specific behaviours

- Five freedoms (from hunger & thirst, discomfort, pain, injury & disease, fear & distress, expression of normal behaviour) FAWC, 1993
Criticism: Exhaustion does not necessarily occur, denies mental involvement (perception) and other response factors
Fight and Flight Syndrome / Alarm Reaction (*Walter Cannon*, 1914)

**ADRENALIN** (Stotz, 1904)

- release triggered by pain, fear etc.
- alimentary canal cease
- shift of blood flow to limbs and CNS, away from GI system
- increase cardiac vigor
- augmentation of blood sugar

*Cannon* (1932): Homeostasis = Maintenance of internal stable condition
Psychophysiology

- describes the body’s physiology to perceived stressors suggesting that the stress response is a mind-body phenomenon (Mason 1971; Lazarus, 1974)

> in contrast to the Selye concept of non-specificity
Classical HPA regulation and sympathetic activation ANS
Stimulus (Stressor)

Coping Pattern
Genetic Disposition
Early Experience

Threat of control
(Fight & Flight)

Amygdala
Behavioural activity
Threat of status or territory

Defense
of territory or social status

Activation of the sympathico-adreno-medullary system

Catecholamines
Corticosteroids
Testosterone

Loss of control
(Depression)

Hippocampus-Septum
Suppression of spatial behaviour and social status

Withdrawal Avoidance
reduced activity; submission; suppression of sexual & maternal behavior

Activation of the pituitary-adrenocortical system

Corticosteroids
Catecholamines
Testosterone

Coping - Predictability Concept
(Henry & Stephens, 1977)
Coping type

depends on individual characteristics, type and duration of stressor, predictability and controllability of the situation

Active Coping: **ANS**
  - Fight & Flight Syndrome
  - restoration of control

Passive Coping: **HPA**
  - inactivity, submission
Homeostasis vs. Allostasis (McEwen, 2003; Korte et al. 2007)

Stability (homeostasis) through change or: remaining stable by being variable

Graph showing the concepts of old and new concept in relation to stress levels and environmental challenges. The graph illustrates the relationship between stressors and animal welfare, highlighting the distinction between homeostasis and allostasis.
Allostatic Load  (McEwen, 1998)
What is stress?

- **old**: any condition that threatens homeostasis
  - Homeostasis: maintenance of a single optimal level
  
  **Stress response**: restoration of balance

- **new**: any condition that throws body out of allostatic balance
  - Allostasis: range of measures appropriate for a situation
Stress Response Components
(modified from Lazarus and Folkman, 1984)

• **Physiological component:** Arousal, hormone secretion, immune response

• **Emotional component:** Anxiety, fear, excitement (positive emotion)

• **Behavioural component:** Coping strategies (both behavioural and mental) - problem focused and/or emotion-focused

> The level of stress experienced depends mainly on the adequacy of the resources for coping and how much they will be drained by the stressful situation
Non-invasive sampling of stress metabolites (mainly glucocorticoids)

from saliva

Non-invasive sampling of stress metabolites (mainly glucocorticoids)

from faeces

Swap Sampling

from Schönreiter & Zanella, 2000

from Möstl & Palme, 2002
Vocal Tag® Rumination activity

Bar-Shalom et al., 2009
Vocal Tag® Ruminating activity

An example for E. Coli Mastitis, first rumen response for a good treatment and later on milk production recovering.

Rumination Rate to Day Zero

The average of Rumination rate before and after calving.

From TMR to Grazing

Decreasing in Rumination rate during the grazing season as an indication for a lack of effective fiber and more exposure to metabolic diseases.

Heat indication

Appetite loss during estrus days

Abomasal Displacement

Abomasal Displacement after calving. Rumen response to surgery, milk production is slowly recovering.

Sub - Clinical Ketosis

The droopy cow syndrome (Dr. Mary Beth de Ondarza) Decreased appetite, no sign in milk production.
What is pain?

- **Pain**: an unpleasant sensory or emotional experience associated with actual or potential tissue damage (IASP)
- **Nociception**: recognition of specific signals, originating in nociceptors and relaying information on tissue damage
Animal Welfare – Prevention of suffering

Knocking Out Pain in Livestock (Adam SHRIVER, Neuroethics 2009)

Two dimensions of pain

Affective dimension
Pain perception as unpleasant suffering (acute pain, chronic pain)

Sensory dimension
Perception of localisation, intensity and quality

Source: according to Shriver, 2009; Layout: © 2010 W. Branscheid
**Animal welfare – Prevention of suffering**

**One-dimensional pain – without suffering**

Knock out of enzymes modulating the affective dimension

Source: according to Shriver, 2009; Layout: © 2010 W. Branscheid
Naked mole rat
(*heterocephalus glaber*)

Evolutionary adaptation to underground habitat (hairless, eyes almost closed, low metabolism)

Mammals (rodents) that do not perceive pain > Skin lacks in substance P mediating pain sensation (> burn, cut)
Assessment of painful procedures?

Grunt

Scream

von Borell et al., 2009
Absolute frequencies of three vocal types of piglets, classified using calibrated and non-calibrated measurements, in different stressful situations (CAS = castration, CAS LA = castration with local anaesthesia, R = restraint, R LA = restraint with local anaesthesia).

von Borell et al., 2009
Eye temperature as a pain indicator
(Stewart, 2008)
Disbudding of calves

Maximum eye temperature (°C) during the 40 min sampling period for control (■, n = 8), local anaesthetic control (▲, n = 8), disbudded with local anaesthetic (□, n = 8) and disbudded without local anaesthetic (●, n = 6). Lines were smoothed using a loess smoother separately for each animal pre and post disbudding. The dashed vertical line indicates the time that local anaesthetic or the sham procedure was administered and 0 min indicates the time of treatment. (Steward et al., 2008)

Explanation: Sympathetic Vasoconstriction
Infrared thermography

Thermal images indicate inflamed tissue, joints, skin & tissue damages, tumors, congestion, blockades
Heart Rate Variability (HRV)

- **Definition:** HRV refers to the beat-to-beat alterations in heart rate.
- **Reduced HRV** has been used as a marker of reduced vagal activity (parasympathetic tone).
- **As a dynamic marker of load,** HRV appears to be sensitive and responsive to acute and chronic stress.
- **Analysis of HRV** offers a non-invasive method of evaluating vagal input into cardiac rhythm.

- **Allostasis:** remaining stable by being variable!
Chinese physician Wang Shuhe wrote: “If the pattern of the heart beat becomes as regular as the tapping of a woodpecker or the dripping of rain from the roof, the patient will be dead in four days...” (3rd Century A.D.)
HRV as a welfare indicator

• HRV in farm animals have been related to pathological conditions, behavioural disorders, management and housing problems, training (horse), temperament and emotional states

• Basic understanding of cardiovascular regulation and model for human diseases

von Borell et al., 2007
Polar Vantage® NV HR Monitor

Protection vest (for pigs)

Receiver (watch) & interface

Transmitter with belt
Positive emotion (eustress)?

Hansen & von Borell, 1999

heart rate variability (RMSSD) [msec]

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Heart Rate Variability</th>
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<tbody>
<tr>
<td>5-10</td>
<td>[20 ± 2]</td>
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<tr>
<td>10-15</td>
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<tr>
<td>15-20</td>
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<tr>
<td>25-30</td>
<td>[26 ± 6]</td>
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<tr>
<td>30-35</td>
<td>[28 ± 7]</td>
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**MASSAGING**

*** p < 0.001
Cognitive enrichment: Call-Feeding-Stations

(Zebunke et al., 2011)
Cognitive bias as an indicator of animal emotion and welfare (Mendl et al. 2009)

• Judgement (valence) in an ambiguous choice situation (glass half-full or half-empty) depend on emotional state

• Physiological correlates of emotional states? (> coping style?)
**Review on animal cognitive bias studies (Düpjan al. 2012)**

**negative bias induced by**
- unpredictable stressors (1)
- loss of enrichment (2)
- depression (2)
- anxiety (3)
- pharmacological stress induction (1)
- 5-HT depletion (1)
- veterinary examination (1)
- individual differences (4)

**positive bias induced by**
- environmental enrichment (3)
- reduced anxiety (1)

Repeated social isolation in pigs did neither induce more pessimistic judgements nor changes in basal cortisol levels or acute cortisol responses (Düpjan, 2012)
Gain of knowledge and applications from stress research

- Quality of the technical and social environment (housing & management)
- Interpretation of behavioural problems
- Adaptive and learning abilities
- Emotional states (positive & negative)
- Interrelationship with health & disease, pain and biological functioning
Conclusions / Outlook

• Behavioural & physiological welfare monitoring with non-invasive techniques
• Combined transponders / sensors (ID, body temperature, HR & activity)
• Acoustic monitoring (rumination, stress calls, coughing, respiration)
• Indicators for positive emotional states?
• Cognitive enrichment and eustress?
• Stress: (still) a concept for reevaluation