Galloping colts, fetal feelings and reassuring regulations – Putting animal welfare science into practice

Professor David J Mellor
Animal Welfare Science and Bioethics Centre
Massey University, Palmerston North, New Zealand

D.J.Mellor@massey.ac.nz

Collaborating Centre for Animal Welfare Science and Bioethical Analysis: Foundation Partner
Major Points

• Introduction
  – Galloping colts – 1967
  – Animal welfare science – from 1990
  – Questions about fetal ‘suffering’ – from 1999

• Fetal feelings – i.e. ‘experienced’ sensations
  – The requirement for both sentience and consciousness

• Neurological development in relation to birth
  – Normal patterns – EEG and critical connections
  – Species differences – Exceptionally & Moderately Immature, Mature
  – What the evidence suggests
  – Fail-safe ‘emergency’ mechanism

• Reassuring regulations
  – Protecting fetal welfare during commercial slaughter of livestock

• Concluding remarks
Present talk based on the following papers:


Introduction:

- **Galloping colts - 1967**
  - Donald Barron’s question
  - Fetal and neonatal physiology – biomedical literature
  - Context: causes and prevention of neonatal lamb mortality
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- Galloping colts - 1967
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  - Context: causes and prevention of neonatal lamb mortality

- Animal welfare science – from 1990
  - General – definitions, reasoning, applications
  - Welfare status assessment and management
  - Pain assessment and alleviation
Introduction:

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  - Fetal and neonatal physiology – biomedical literature
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• Animal welfare science – from 1990
  - General – definitions, reasoning, applications
  - Welfare status assessment and management
  - Pain assessment and alleviation

• Questions about fetal ‘suffering’ – from 1999
  - ‘Drowning’ in amniotic fluid after slaughter of the dam
  - Feeling pain during calf serum collection at slaughter
  - Question: Can fetuses experience unpleasant sensations?
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• Concluding remarks
Fetal feelings – i.e. ‘experienced’ sensations

- Welfare status is what the animal experiences
  - Internally generated sensations or ‘feelings’
    - Sensory scanning of animal’s functional state
    - Thirst, hunger, breathlessness, pain, nausea, malaise, sickness and others
  - Externally focused inputs via sensory modalities of sight, hearing, smell, taste, touch, thermal comfort, etc
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• Pre-requisites of good welfare and suffering
  - Sentience
    - Phylogenetic status – not relevant, mammals only
    - The developmental stage of the neural apparatus
    - Must have achieved sufficient functional maturity
  - Consciousness
    - The brain must be in a state of consciousness
    - Experiencing sensations depends on consciousness
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Neurological development in relation to birth:

- Normal patterns – EEG and critical connections

  - EEG – *six stages*
    1. Electrical silence - isoelectric
    2. Spikes punctuating isoelectric trace
    3. More sustained but intermittent activity

Wallaby Joeys

Percentage isoelectric EEG

Intermittent EEG epochs separated by silent periods – 30-second trace
Neurological development in relation to birth:

- Normal patterns – EEG and critical connections

- EEG – *six stages*
  1. Electrical silence - isoelectric
  2. Spikes punctuating isoelectric trace
  3. More sustained but intermittent activity
  4. Continuous mixed activity
  5. Differentiated REM-non-REM activity

90-day fetal sheep – 0.6

120-day fetal sheep – 0.8
Neurological development in relation to birth:

- Normal patterns – EEG and critical connections
  
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    5. *Essential thalamic-cortical connections*
    6. REM-non-REM sleep/wakefulness cycles
Neurological development in relation to birth:

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  - EEG – *six stages*
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- *Stages 1 to 5: incompatible with consciousness*

- *Stage 6: consciousness is punctuated by sleep*
Neurological development in relation to birth:

- Species differences at birth
  - Neurologically exceptionally immature – stage 1
  - Marsupial joeys
  - First become conscious several months after birth
  - No capacity for consciousness before birth
Neurological development in relation to birth:

- **Species differences at birth**
  - **Neurologically exceptionally immature – stage 1**
    - Marsupial joeys
    - First become conscious several months after birth
    - *No capacity for consciousness before birth*

- **Neurologically moderately immature – stages 2-4**
  - Kittens, puppies, rabbit kits, rat & mouse pups
  - First become conscious 4-14 days after birth
  - *No capacity for consciousness before birth*
Neurological development in relation to birth

- **Species differences at birth**
  - Neurologically *exceptionally* immature – stage 1
    - Marsupial joeys
    - First become conscious *several months* after birth
    - No capacity for consciousness before birth
  - Neurologically *moderately* immature – stages 2-4
    - Kittens, puppies, rabbit kits, rat & mouse pups
    - First become conscious *4-14 days* after birth
    - No capacity for consciousness before birth
  - Neurologically *mature* – stage 6
    - Calves, fawns, foals, kids, lambs, piglets, guinea-pig pups
    - First become conscious *minutes to hours* after birth
    - Capacity for consciousness before birth
    - BUT unconsciousness maintained by in utero neuroinhibitors
Birth and neurological developmental stage

Three levels of neurological maturity at birth/hatching

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<thead>
<tr>
<th>Exceptionally immature</th>
<th>Moderately immature</th>
<th>Mature</th>
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<tbody>
<tr>
<td>EEG silence</td>
<td>Spikes-short epochs</td>
<td>Continuous</td>
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<thead>
<tr>
<th>Stage 1</th>
<th>Stages 2 &amp; 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
<th>Stage 6</th>
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<tr>
<td>Mammalian newborns</td>
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<td>Marsupial joeys:</td>
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<td>- Tammar wallaby</td>
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<td>- Virginia opossum</td>
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<td>- Virginia opossum</td>
<td>Mouse pup</td>
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<td>Rat pup</td>
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<td>Lamb#</td>
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<td>Rabbit kit</td>
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<td>Piglet#</td>
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<td>Guinea-pig pups#</td>
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<td>Human infant#</td>
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<td>Pigeon</td>
<td>Domestic chicken</td>
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REM = rapid-eye-movement sleep

*In utero* neuroinhibitors operate until birth
Neurological development in relation to birth

- Neurologically *exceptionally immature* – stage 1

  ![Day 6](image1) ![Day 70](image2) ![Day 185](image3) ![Day 220](image4)

- Neurologically *moderately immature* – stages 2-4

  ![Day 3](image5)
Neurological development in relation to birth

- Neurologically mature – stage 6

Lamb birth sequence

0 min

< 1 min

15-25 min

~3 min

7-10 min
Conclusions about fetal/newborn unconsciousness

- The evidence suggests that:
  - No *fetus* is conscious before or during birth
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  - Depending on the species, this occurs after months, days or minutes-hours
  - Thereafter, noxious sensations can be experienced and welfare can be compromised
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  - The *newborn* cannot experience unpleasant sensations until after the onset of consciousness
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• Some people take the opposite view:
  - That the fetus *is* conscious and *can* suffer before birth
  - That fetal welfare therefore *can* be compromised
  - Some mothers, midwives, pediatricians, veterinarians, animal ethics committee members
  - Also, some researchers studying fetal pain

• So, what about humane slaughter of livestock fetuses?
Fail-safe ‘emergency’ mechanism protects the welfare of livestock fetuses:

- Oxygen supply to the fetal brain is the key
  - The fetus has no control over placental $O_2$ supply
  - Fetal brain is vulnerable to $O_2$ shortage
  - Three mechanisms minimise fetal brain $O_2$ use:
    1. *Fetal unconsciousness* – lowers brain $O_2$ use by 10-40% – provides a background ‘safety margin’
    2. *Switch towards the non-REM state* just before and during labour reduces brain $O_2$ use – prepares for likely $O_2$ shortages during labour
    3. *Emergency shut-down* of cerebral cortical electrical activity in response to cessation of placental $O_2$ supply
Fail-safe ‘emergency’ mechanism protects the welfare of livestock fetuses:

- **Emergency shut-down of cortical electrical activity:**
  - Umbilical cord occlusion *stops* $O_2$ *supply* to the fetus
  - EEG becomes *isoelectric* well within 60-90 seconds
  - *This is completely incompatible with consciousness*


- When the $O_2$ supply is restored cortical function returns
- Within 5-6 minutes – without major neuronal damage
- After >10 minutes – with progressively greater damage
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- **Concluding remarks**
Reassuring regulations for livestock slaughter:

• Cord occlusion simulates maternal neck-cut slaughter
  - Neck-cut causes a catastrophic loss of maternal blood
  - Blood and O₂ supply to the uterus ceases rapidly
  - *Placental O₂ supply to the fetus ceases*
  - Fetal cerebral cortical ‘shut-down’ occurs within 60-90 sec
  - ‘Shut-down’ will continue if O₂ supply is NOT restored
  - *The isoelectric EEG guarantees unconsciousness*
  - Such fetuses CANNOT experience any sensations
    - *Breathlessness* while ‘drowning’
    - *Pain* due to needling while collecting fetal serum

• This scientific understanding underpins regulations
Reassuring regulations for livestock slaughter:

• The regulations are designed to ensure that:
  - Fetuses are not removed too soon after death of the dam
  - Fetuses never successfully breathe air
  - The fetal EEG will remain isoelectric until fetal death

• OIE fetal slaughter regulations:
  - No living fetus should be removed from the uterus sooner than 5 minutes after the maternal neck or chest cut.
  - The successful onset of breathing should be prevented, e.g. by clamping the trachea.
  - Or the fetus should be left in the uterus for 15-20 minutes – anoxic brain damage would then be substantial.
  - Or the fetus should be left in the uterus until it is dead.
  - If there is any doubt about consciousness, the fetus should be killed with a suitably sized captive bolt, or a blow to the head with a suitable blunt instrument.
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Concluding remarks – multi-disciplinarity

• ‘Non-AWS’ *fetal-neonatal* sources:
  - Most papers were in the biomedical literature.
  - Fetal sheep have been the preferred ‘model’ for human research for at least 50 years.
  - The behavioural, veterinary or AWS literature provided virtually no relevant information.
  - *Highlights the value of multi-disciplinary perspectives.*
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• *Animal welfare and pain sources:*
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• *A fortuitous coincidence of interests:*
  - The combination of fetal-neonatal, animal welfare science and pain physiology interests provided this outcome.
Concluding remarks – multi-disciplinarity

- ‘Non-AWS’ fetal-neonatal sources:
  - Provided most direct information for framing and justifying the regulations or guidelines for the humane management of livestock fetuses during slaughter of their dams.
  - This is probably quite unusual.
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• AWS, behaviour, veterinary and pain sources:
  - In contrast, there is purposefully commissioned animal-based research. It provides direct scientific bases for codes of practice, welfare codes or regulations – e.g. those on the management of painful husbandry practices in livestock.
  - This would be a much more usual pattern.
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• *Science is not the only determinant:*
  - Practical experience, common sense, ease of use, available technology, clarity of instructions, costs and other factors must also be considered.