# 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***

AWSBC

Massey University

# *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:


**Mellor DJ & Gregory NG (2003). Responsiveness, behavioural arousal and awareness in fetal and newborn lambs: experimental, practical and therapeutic implications. *New Zealand Veterinary Journal* 51, 2-13.**

**Mellor DJ, Diesch TJ, Gunn AJ & Bennet L (2005). The importance of "awareness" in understanding fetal pain. *Brain Research Reviews* 48, 455-471.**

**Mellor DJ & Diesch TJ (2006). Onset of sentience: potential for suffering in fetal and neonatal farm animals. *Applied Animal Behaviour Science* 100, 45-57.**

**Mellor DJ & Diesch TJ (2007). Birth and hatching: key events in the onset of awareness in lambs and chickens. *New Zealand Veterinary Journal* 55, 51-60.**

**Mellor, D.J., Diesch, T.J., Gunn, A.J. and Bennet, L (2008). Fetal 'awareness' and 'pain': what precautions should be taken to safeguard fetal welfare during experiments? *AATEX Journal* 14, Special Issue, 79-83.**

**Diesch, T.J., Mellor, D.J., Johnson, C.B. and Lentle, R.G. (2008). Responsiveness to painful stimuli in anaesthetised newborn and young animals of varying neurological maturity (wallaby joeys, rat pups and lambs). *AATEX Journal* 14, Special Issue, 549-552.**

**Murrell, J.C., Mellor, D.J. and Johnson, C.B. (2008). Anaesthesia and analgesia in the fetus and newborn. *Anesthesia and Analgesia in Laboratory Animals,* 2nd Edition, pp 593-608. R.E. Fish, P.J. Danneman, M.J. Brown, A.M. Karas, Eds, Elsevier, Academic Press, New York, USA.**

**Diesch, T.J., Mellor, D.J., Johnson, C.B. and Lentle, R.G. (2009). Electroencephalographic responses to tail clamping in anaesthetised rat pups. *Laboratory Animals*, 43, 224-231.**

**Mellor, D.J., Patterson-Kane, E. and Stafford, K.J. (2009) Integrated perspectives: sleep, developmental stage and animal welfare. In *The Sciences of Animal Welfare*. Oxford: Wiley-Blackwell, pp 161-185.**

# Introduction:

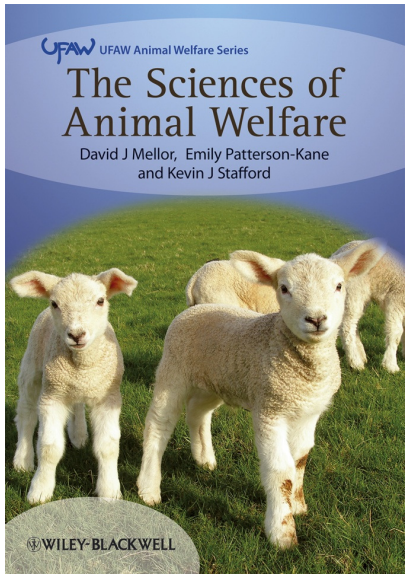
- **Galloping colts - 1967**
  - Donald Barron's question
  - Fetal and neonatal physiology – biomedical literature
  - Context: causes and prevention of neonatal lamb mortality

Massey University

AWSBC

# Introduction:

- Galloping colts - 1967
  - Donald Barron's question
  - Fetal and neonatal physiology – biomedical literature
  - 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**




Massey University

AWSBC

# Introduction:

- Galloping colts - 1967
  - Donald Barron's question
  - Fetal and neonatal physiology – biomedical literature
  - 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
- **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?**

Massey University

AWSBC

# *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**

# 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**

# 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

- **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**

Massey University

AWSBC

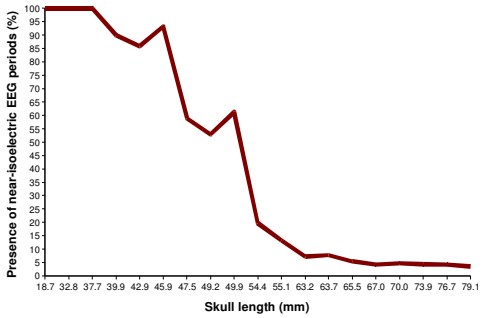
# *Major Points*

- **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**

# 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**

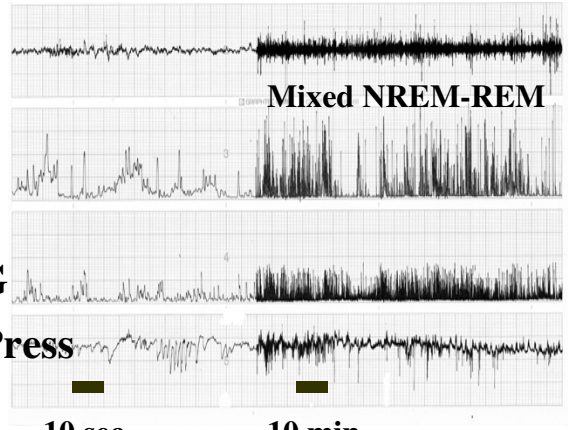
Massey University

AWSBC

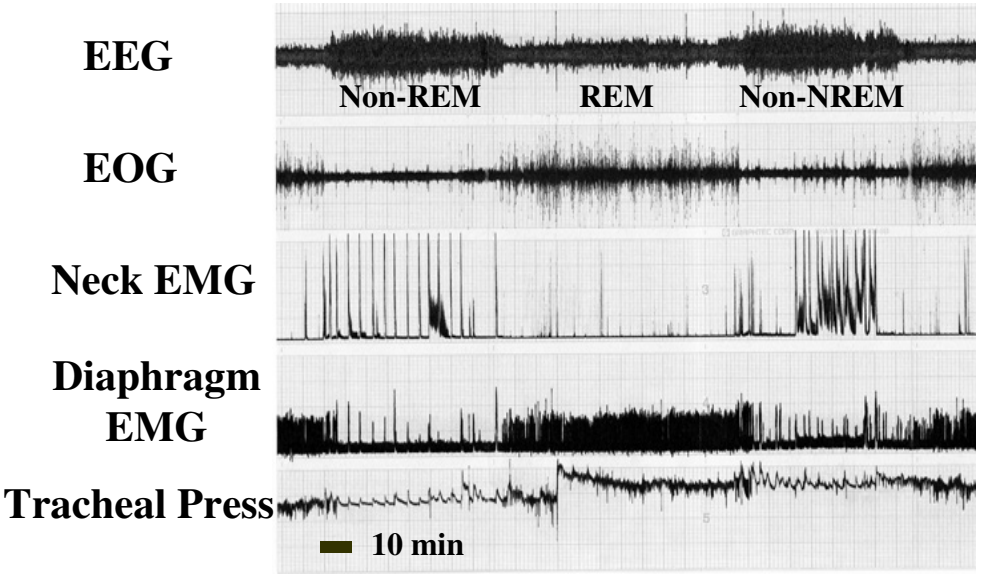
# Neurological development in relation to birth:

- **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**
  - **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**

    5. ***Essential thalamic-cortical connections***

    6. **REM-non-REM sleep/wakefulness cycles**

# 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**

    5. ***Essential thalamic-cortical connections***

    6. **REM-non-REM sleep/wakefulness cycles**

- ***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*

Massey University

AWSBC

# Birth and neurological developmental stage

## Three levels of neurological maturity at birth/hatching

| *Exceptionally immature* | *Moderately immature* | *Mature* |
|---|---|---|

**EEG silence → Spikes-short epochs → Continuous → REM-non-REM → sleep-wake cycles**

*Stage 1* *Stages 2 & 3* *Stage 4* *Stage 5* *Stage 6*

*Mammalian newborns*

| | | |
|---|---|---|
| ↑ | ↑ ↑ ↑ ↑ | ↑ |
| Marsupial joeys:<br>- Tammar wallaby<br>- Virginia opossum | Kitten<br>Puppy<br>Mouse pup<br>Rat pup<br>Rabbit kit | Calf#<br>Fawn#<br>Foal#<br>Kid#<br>Lamb#<br>Piglet#<br>Guinea-pig pups#<br>Human infant# |

*Avian hatchlings*

| | |
|---|---|
| ↑ | ↑ |
| Pigeon | Domestic chicken |

REM = rapid-eye-movement sleep

#*In utero* neuroinhibitors operate until birth

Massey University

AWSBC

# Neurological development in relation to birth

- Neurologically *exceptionally immature* – stage 1

Day 6

Day 70

Day 185

Day 220

- Neurologically *moderately immature* – stages 2-4

Day 3

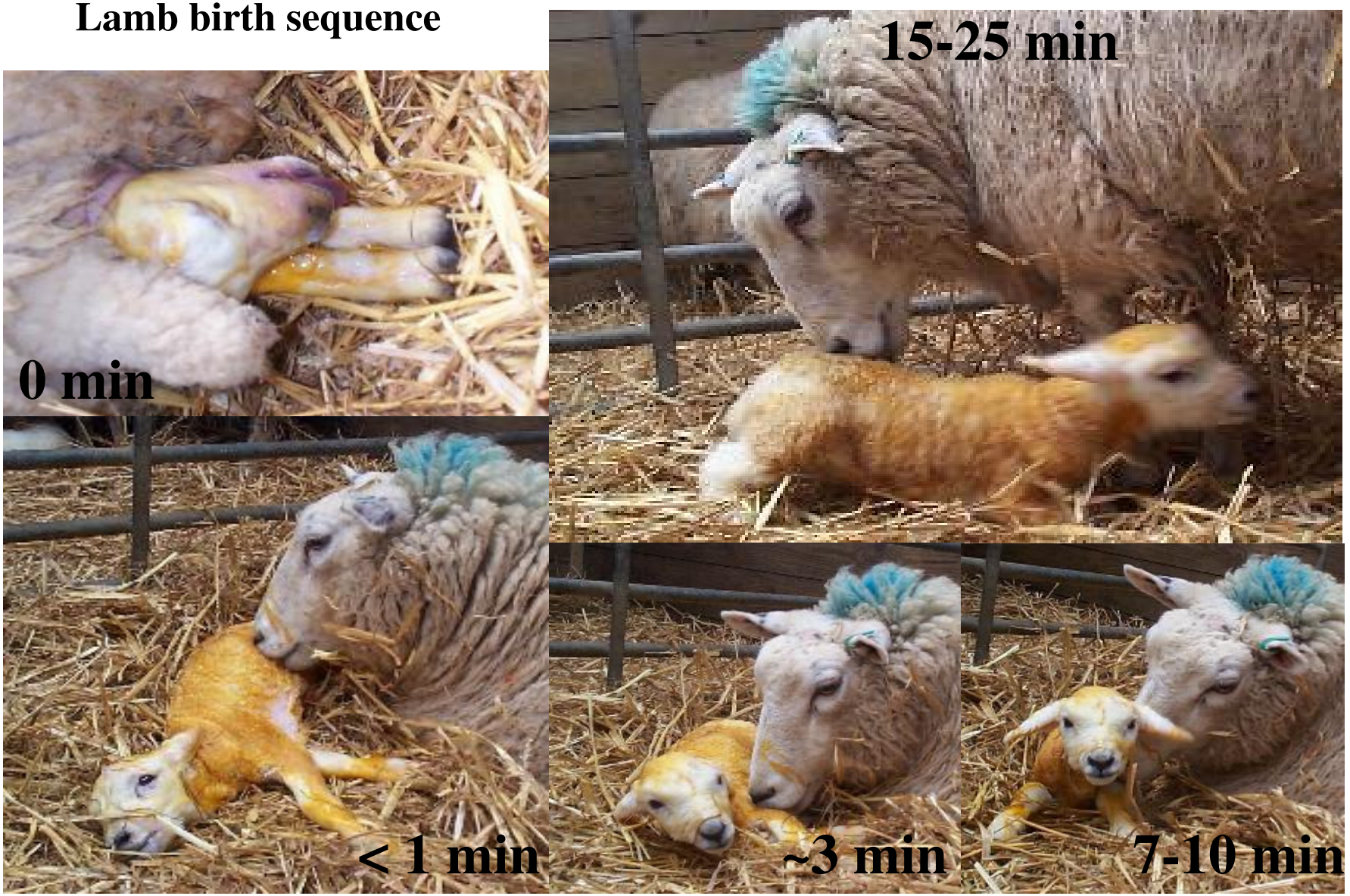
Massey University

AWSBC

# Neurological development in relation to birth

- Neurologically *mature* – stage 6

**Lamb birth sequence**



# Conclusions about fetal/newborn unconsciousness

- **The evidence suggests that:**
  - **No *fetus* is conscious before or during birth**
  - **Fetal welfare therefore cannot be compromised**

# Conclusions about fetal/newborn unconsciousness

- **The evidence suggests that:**
  - **No *fetus* is conscious before or during birth**
  - **Fetal welfare therefore cannot be compromised**
  - **The *newborn* cannot experience unpleasant sensations until after the onset of consciousness**
  - **Depending on the species, this occurs after months, days or minutes-hours**
  - **Thereafter, noxious sensations can be experienced and welfare can be compromised**

# Conclusions about fetal/newborn unconsciousness

- **The evidence suggests that:**
  - No *fetus* is conscious before or during birth
  - Fetal welfare therefore cannot be compromised
  - The *newborn* cannot experience unpleasant sensations until after the onset of consciousness
  - Depending on the species, this occurs after months, days or minutes-hours
  - Thereafter, noxious sensations can be experienced and welfare can be compromised

- **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?**

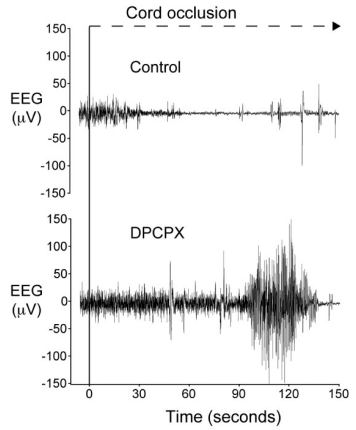
# Fail-safe 'emergency' mechanism protects the welfare of livestock fetuses:

- **Oxygen supply to the fetal brain is the key**
  - ***The fetus has <u>no</u> control* over placental $O_2$ supply**
  - **Fetal brain is *vulnerable to $O_2$ shortage***
  - **Three mechanisms *minimise fetal brain $O_2$ use:***
    1. ***<u>Fetal unconsciousness</u>* – lowers brain $O_2$ use by 10-40% – provides a *background 'safety margin'***
    2. ***<u>Switch towards the non-REM state</u>* just before and during labour reduces brain $O_2$ use – prepares for likely $O_2$ shortages during labour**
    3. ***<u>Emergency shut-down</u>* 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***

**Hunter et al (2003).**
***Stroke* 34: 2240-2245**




- **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**

Massey University

AWSBC

# *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**

# Reassuring regulations for livestock slaughter:

- **Cord occlusion simulates maternal neck-cut slaughter**
  - **Neck-cut causes a catastrophic loss of maternal blood**
  - **Blood and $O_2$ supply to the uterus ceases rapidly**
  - ***Placental $O_2$ supply to the fetus ceases***
  - **Fetal cerebral cortical 'shut-down' occurs within 60-90 sec**
  - **'Shut-down' will continue if $O_2$ 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**

Massey University

AWSBC

# 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.***

# *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**

# 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.***

# 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.***
- ***Animal welfare* and *pain* sources:**
  - **Animal behaviour, veterinary or AWS literature provided most relevant information, as well as human pain literature.**
  - ***This too required multi-disciplinary perspectives.***

Massey University

AWSBC

# 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.***
- ***Animal welfare* and *pain* sources:**
  - **Animal behaviour, veterinary or AWS literature provided most relevant information, as well as human pain literature.**
  - ***This too required multi-disciplinary perspectives.***
- **A *fortuitous coincidence* of interests:**
  - **The combination of fetal-neonatal, animal welfare science and pain physiology interests provided this outcome.**

Massey University

AWSBC

# 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.***

# 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.***
- ***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.***

# 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.***
- ***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.***
- **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.**

Massey University

AWSBC