Reproductive management by the continuous body temperature measurement in cattle: focusing on the reproductive hormonal change

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Today’s Topic

1. Why do we need the ICT for reproductive management in cattle industry?

2. Relationship between body temperature and reproductive hormone level

3. Detection of the estrus by body temperature measurement

4. Prediction of calving by body temperature measurement
1. Why do we need the ICT for reproductive management in cattle industry?
Estrus detection rate is decreasing

In dairy cattle
Milk yield ↑
Standing heat ↓
Pregnancy rate ↓

- Weak estrus symptoms
  = difficult to detect the estrus by observation
- Cannot breed at the proper timing
  = unsuccess of fertilization
  = low pregnancy rate

Needs aids to detect the estrus precisely for proper AI.
If conception rate is same, the pregnancy rate would depend on **the estrus detection (# of breeding)**.

\[
\text{Pregnancy rate (\%)} = \text{Productivity}
\]

**Detection of estrus is important** for proper breeding and increase in productivity.
Calving management has several problems

- Needs labor for night watch
  - more than 40% of calving start in night time (Nakao et al. 1992)

- High rate of calving difficulty (dystocia and stillbirth)
  - needs extra labor for farmers, hit the economy (Martin-Collado et al. 2017)

Precise detection (prediction) of calving is important to lower problems

<table>
<thead>
<tr>
<th>% of calving difficulty in dairy cattle in Hokkaido (2007)</th>
<th>Rate of stillbirth in Japan (2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>Heifer</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Dairy</td>
<td>33.3</td>
</tr>
<tr>
<td>Beef</td>
<td>34.4</td>
</tr>
<tr>
<td>Total</td>
<td>32.3</td>
</tr>
</tbody>
</table>

Dystocia ⇒ increase calf and cow mortality
decrease milk production
delay of reproductive recovery

Stillbirth ⇒ decrease income (beef and dairy)

Directly hit farmers’ economy.
**Concept & our goal:** utilization of low-invasive devices for reproduction management

- **Non-invasive Sensors/Devices without restriction**
  - Vaginal temperature
  - Skin temperature
  - Pedometer
  - Accelerometer

**Physiological data**
- Body temperature
- Activity
- Live imaging

**AI Deep Learning Cloud computing**

- Raw data
- Analyzed data

1. Estrus detection
2. Prediction of calving

**Good Management**
- Labor-saving → don’t need night watch
- Appropriate assistant → decrease of dystocia & stillbirth
- Breeding at proper time → Increase of pregnancy rate

**Data sharing**
(farmers • veterinarian)
2. Relationship between body temperature and reproductive hormone level
Body temperature and reproductive hormone level

Body temp reflects:
- metabolism
- inflammation
- endocrine secretion

**Temperature Elevation**

**Periodic temperature change**

Body temperature change during estrus (actual measured value)

Is estrus detected by measurement of body temp.?
Daily body temp change and LH surge around estrus in dairy cows

P4 maintains body temperature high level

① Before estrus ⇒ CL regression = P4↓ = body temperature ↓
② Before calving ⇒ Pregnant CL regression (P4↓) = body temperature ↓
LH elevates body temperature dramatically (?)

Q1: Can we detect estrus or calving by the measurement of body temp?

Q2: Which temperature is suitable for the continuous measurement without restraint?

Vagina is most suitable.
1. Easy insertion of thermometer
2. Less affected by ambient temp.

(Theriogenology 2008 Fisher et al.)
Body temperature reflect the reproductive hormone level.

- Transient elevation of body temp. $\Rightarrow$ LH surge or E2
  $\Rightarrow$ detection for Estrus

- High body temp. $\Rightarrow$ High progesterone (P4)
- Low (decrease) body temp. $\Rightarrow$ Low P4 (regressed CL)
  $\Rightarrow$ detection of Estrus
detection the onset of calving

Body temperature would be useful for reproductive management.
3. Detection of the estrus by body temperature measurement
Vaginal temperature elevation during the estrus

Hourly average vaginal temperature during estrus (n=25, JB)

Typical vaginal temperature change during 3 estrus cycles

Sakatani et al., 2012
Setting threshold at 0.3°C (Day0 – Day-1) enables to detect the estrus precisely. (Day 0 = Day of Estrus)

- Estrus synchronizations (hormonal treatment) make clear vaginal temperature elevation.

- The estrus symptom (STBM) decreased by heat stress (summer).

Is measurement of body temperature effective to detect the estrus under heat stress?
Estrus detection by body temp is less affected by heat stress

<table>
<thead>
<tr>
<th></th>
<th>Cool season</th>
<th>Hot season</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedometer</td>
<td>81.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>65.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>73.3&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vaginal temp.</td>
<td>100.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>91.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>95.7&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a-b</sup> P<0.05 between vaginal temp and pedometer

- Estrus detection rate;

  *Vaginal temperature > Pedometer*

  Vaginal temperature was less affected by heat stress.

  (= stably **high rate (>90%)** regardless of the season)

**Measurement of vaginal temperature could be an effective method to detect the estrus throughout the year.**
4. Prediction of calving by body temperature measurement
Calving detection by measurement of body temperature

Hormonal change around calving

- **Progesterone (P4)** ⇒ decrease from -40h of calving
- **Vaginal temperature** ⇒ decrease from -40h of calving
- **Temp decrease = P4 decrease** ⇒ detect the onset of calving
- Possible to predict the calving!

Lammoglia et al. 1997 J Anim Sci
Body temperature change before calving (beef cattle: Japanese Black)

**Vaginal temp change (n=60)**

- **Temp difference (vs -48h)**
  - p<0.05 vs -48h
  - Threshold = -0.3°C

Compared with 48 h prior to second alert,

1. **Threshold = -0.3°C**: -24 prior to second alert
2. Body temp increase as the beginning of the contraction

**Vaginal temp measurement is effective to detect the onset of calving.**
# Measurement of body temp. can predict at 24 h before calving

## The result of commercial beef cattle farm in Japan

<table>
<thead>
<tr>
<th></th>
<th>Time1 First〜Second (hh:mm)</th>
<th>Time2 Second〜calving (hh:mm)</th>
<th>Time1+Time2 (hh:mm)</th>
<th>Pregnancy period (d)</th>
<th>Calf BW (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td>21:59 ± 7:07</td>
<td>2:06 ± 2:49</td>
<td>26:27 ± 0:20</td>
<td>290.4 ± 4.4</td>
<td>37.5 ± 5.3</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>22:27</td>
<td>1:18</td>
<td>25:52</td>
<td>290</td>
<td>37.5</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>552 (88.3)</td>
<td>621 (99.4)</td>
<td>548 (87.7)</td>
<td>625 (100)</td>
<td>641* (100)</td>
</tr>
</tbody>
</table>

Total 625 parturition *includes 17 twins

- Threshold = -0.4°C  
  ⇒ prediction at 24 h before calving (detection rate = 90%)
- 1 to 2 h prior to calving ⇒ Alert of rupture of membrane (99%)  
  ⇒ enable to do appropriate assistance

Sakatani et al., 2018
Measurement of body temp. might predict the calving difficulty

The result of commercial beef cattle farm in Japan

<table>
<thead>
<tr>
<th>Calving</th>
<th>Pregnancy period (d)</th>
<th>BW</th>
<th>Male (%)</th>
<th>Female (%)</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>spontaneous</td>
<td>290.2±4.3</td>
<td>36.42±4.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>163 (43.5)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>212 (56.5)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>375 (60.0)</td>
</tr>
<tr>
<td>Mild assistance</td>
<td>291.0±4.4</td>
<td>38.99±5.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>131 (59.3)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>90 (40.7)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>221 (35.4)</td>
</tr>
<tr>
<td>Dystocia</td>
<td>289.8±5.7</td>
<td>39.52±8.91&lt;sup&gt;b&lt;/sup&gt;</td>
<td>17 (60.7)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11 (39.3)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>28 (4.5)</td>
</tr>
</tbody>
</table>

<sup>a-b: P<0.05</sup>

Still birth 0.96% (6/625)

**spontaneous ⇒ assist ⇒ dystocia**

- extend the calving time
- **heavier body weight** of calves
- **higher rate of male** calves

Sakatani et al., 2018 Theriogenology
Continuous measurement of body temperature is useful for reproductive management.

1. Well reflect the reproductive hormone level (Progesterone, LH).
2. Detect estrus at high rate (regardless of season).
3. Predict the onset of calving (24h before calving).

It could contribute to improve the breeding and conception rates, and decrease the calving accidents caused by calving difficulty.

Future subject:

- The utility consideration for health management including reproductive problems.
- Development of more non-invasive devices. (vaginal measurement has a risk for inflammation)
- Development of easier set-up/detach devices.
Acknowledgement

Dr. Naoki Takenouchi
Dr. Takuo Hojo

Dr. Masafumi Miwa

Dr. Masashi Takahashi

Beef cattle section staff of
Kyushu Okinawa Agricultural Research Center, NARO
Institute of Livestock and Grassland Science, NARO

NTT docomo
Kimotsuki-Daichi Farm

The Project of the NARO Bio-oriented Technology Research Advancement Institution
(The Special Scheme to Create Dynamism in Agriculture, Forestry and Fisheries through Deploying Highly Advanced Technology)
Thank you!