THE CONDUCTIVITY OF CERVICAL MUCUS AS A PREDICTOR OF OVULATION
IN BEEF COWS SYNCHRONISED WITH CLOPROSTENOL

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Receipt of MS 16-06-1980

(Key words: Cervical mucus, oestrus detection, beef)
(Sleutelwoorde: Servikale mukus, estrus waarneming, vleisbeeste)

OPSOMMING:
DIË GELIJKBAARHEID VAN DIE SLIRVIKAI MUKUS AS 'N VOORSPELLER VAN OVULASIE BY VLEIS-BEESTE WAT MET CLOPROSTENOL GESINKRONISEER IS

'n Kommersiële geleisbaarheidsmeter is gebruik om die veranderinge in die elektriese geleisbaarheids van die servikale mukus van Mashona- en Afrikanerkoes wat met cloprostenol gesinkroniseer is, te monitor en 'n poging om die optimale tyd vir kunsmatige inseminasie te voorspel. Geleisbaarheds leesings het 'n laagtepunt net voor of tydens bronstigheid bereik: 'n patroon en pele wat ooreenstem met die met-die van ander werkers. Geen verskil in patroon of peel van geleisbaarheid is tussen rasse of tussen koes wat beset of nie beset geraak het, waargeneem nie. Daar was ook geen verskille tussen die koes wat teken van bronstigheid getoon en die wat dit nie getoon het nie. Inseminasie tydens die stadium van laagste geleisbaarheid na 2 inspuitings van cloprostenol 11 dae na mekaar het 'n hoër besettingsyfer gegee as inseminasie op 'n tydsbasis van 72 en 96 h, naamlik vir die Mashonakoos 57 teenoor 40 persent en vir die Afrikaners 42 teenoor 19 persent. Inseminasie by waargeneem oestrus na enkele cloprostenolsinspuiting gevolg deur 'n verdere inspuiting of inseminasie op 'n tydsbasis vir die koë wat nie op die aanvanklike inspuiting gereageer het nie, het gedurende die drei dae na die laagste geleisbaarheids leesing 69 persent van die Mashonas en 81 persent van die Afrikaners beset geraak. Die oorwydendes het beset geraak na inseminering 30 h daer nadie laagste geleisbaarheid leesing. Tussen 30 h en 40 h van die koë van beide rasse het die laagste geleisbaarheids leesing op die dag voor bronstigheid gehad. Van hierdie koë het beset geraak na inseminasie tydens laagste geleisbaarheid en daardie inseminasies het 57 en 40 persent van die Mashonas en 42 en 19 persent van die Afrikaners beset. Van hulle koë van beide rasse het die laagste geleisbaarheid leesing na inseminasie tydens laagste geleisbaarheid gevestig en daardie inseminasies het 57 en 40 persent van die Mashonas en 42 en 19 persent van die Afrikaners beset. Van hulle koë van beide rasse het die laagste geleisbaarheid leesing na inseminasie tydens laagste geleisbaarheid gevestig en daardie inseminasies het 57 en 40 persent van die Mashonas en 42 en 19 persent van die Afrikaners beset. Van die inseminasies het 69 persent van die Mashonas en 81 persent van die Afrikaners beset. Van die inseminasies het 69 persent van die Mashonas en 81 persent van die Afrikaners beset.

SUMMARY:
A commercial conductivity detector was used to monitor the changes in the conductivity of the cervical mucus in Mashona and Afrikaner beef cows synchronised with cloprostenol in an attempt to predict the optimum time for artificial insemination. The recorded conductivity values, prior to, during and after oestrus were of a similar level and pattern to those found by other workers, the nadir occurring at or close to oestrus. There were no differences in the pattern or level of conductivity readings between breeds nor in those from animals that conceived and those that did not. Similarly, there were no differences between animals that displayed signs of oestrus and those that did not. Insemination to the lowest conductivity reading, after two cloprostenol injections 11 days apart, gave higher conception rates for both Mashona and Afrikaner cows (57 and 40 per cent), than fixed-time inseminations at 72 and 97 h (42 and 19 per cent), or insemination to observed oestrus after a single cloprostenol injection, followed by a further injection and fixed-time insemination for those not responding to the initial injection (50 and 19 per cent). Of those animals inseminated to lowest conductivity readings, 69 per cent of the Mashonas and 83 per cent of the Afrikaner conceived to inseminations at the nadir, the remainder conceived to inseminations on the day after the nadir. In both breeds 30 to 40 per cent of animals showed their lowest conductivity reading on the days prior to the onset of oestrus. Insemination of these animals to their lowest reading resulted in a proportion conceiving which suggests that in some cows fertile ovulation occurs substantially earlier than the onset of behavioural oestrus. The broad temporal spread of onset of oestrus and lowest conductivity readings, 48 to 168 h after the second synchronising injection, will also mitigate against high conception rates from any combination of two fixed-time inseminations in these breeds of cow.

The problem of oestrus detection is the major drawback to the implementation of artificial insemination (AI) programmes in beef cattle (Britt, 1979). The advent of methods for synchronisation of oestrus followed by AI have improved the situation under certain conditions (Britt, 1979). However, these systems have yet to provide consistently acceptable results in cycling beef cows in Zimbabwe (Ward, H.K., personal communication) and elsewhere in Africa (Trail, Sacker & Fisher, 1971; Buck, Light & Makobo, 1980), particularly with regard to fixed-time insemination after synchronisation.

Numerous aids for the detection of oestrus have been described, though visual observation has invariably
proved the most efficient and consistent despite its inherent uncertainties (Donaldson, 1968; King, Humik & Robertson, 1976). Accurate visual detection of oestrus requires frequent observation of groups of cows, as oestrus can commence at any time and may be less than 4 hours duration (King et al., 1976; Williamson, Morris, Blood & Cannon, 1972) and is therefore not suitable for large herds under extensive ranching conditions (Buck, Serema & Staugaard, 1975; Buck et al., 1980).

The vaginal-cervical mucus in cows undergoes many changes during the oestrous cycle (Norman, Schultze & Ellington, 1975) and of these changes, the electrical conductivity has received considerable attention as an aid for oestrus detection (Edwards & Levin, 1974; Foote, 1975; Gartland, Schiavo, Hall, Foote & Scott, 1976; Schams, Schallenger, Hoffman & Karg, 1977; Heckman, Katz, Foote, Otternacu, Scott & Marshall, 1979). The change in electrical conductivity of the mucus at or about oestrus is closely related to the endocrine events occurring at the same time (Owen, 1978).

The present study was conducted to evaluate the potential of an 'oestrus' detector based on the measurement of the conductivity of cervical mucus for improving conception rate in synchronised Afrikaner and Mashona beef cows.

Procedure

The 'oestrus' detector used in this trial was that described as a ring-electrode type (Gartland et al., 1976) and is commercially available as the AHD-I Heat Detector (ABS (Pty.) Ltd., Pretoria, South Africa). The probe was inserted fully into the cow's vagina so that the electrodes were close to the cervical os (Owen, 1978) and moved around to record the lowest consistent reading. The detector probe was cleaned and calibrated after every 10 readings and was placed in disinfectant between cows. Before the probe was inserted into the next cow it was rinsed with clean water. The probing and reading took between 45 and 90 seconds per cow. It was found essential not to allow air into the vagina as erroneously high values resulted. All readings were made by one operator. During the luteal phase of the oestrous cycle, conductivity readings as quoted by the distributor (ABS (Pty.) Ltd South Africa) should be of the order of 80-100; during oestrus itself values should fall to about 35 (ABS (Pty.) Ltd., South Africa).

Visual observation of oestrus

All animals were observed continuously from 0600 – 1800 h daily during the treatment period for signs of behavioural oestrus by 3 specially trained stockmen. The type of activity seen and the cows involved were noted independently by the stockmen at half hourly intervals. Signs of mucus discharge from the vagina, uterine tone and condition of the cervix were also noted during probing and at insemination.

Experimental animals and treatments

Seventy-two Mashona and 48 Afrikaner lactating cows of which 24 Mashonas and 16 Afrikanners were assigned randomly to each of 3 groups were used in the experiment. All animals were at least 75 days post partum at the start of the experiment (January, 1979) and cyclic ovarian function was confirmed by rectal palpation at 10 intervals.

The control group (Group 1) received 2 intramuscular injections, each of 2 ml, of the synthetic analogue of prostaglandin F2a, cloprostenol (Estrumate, I.C.I. Pharmaceuticals Ltd.), 11 days apart (Dobson, Cooper and Furr, 1975), and were inseminated at 72 h after the last injection with Mashona semen and at 96 h with Hereford semen.

In Group 2 animals, the conductivity readings were taken each morning (0830 – 1000 h) after having received the same cloprostenol treatment as Group 1. The animals were inseminated when the conductivity reading dropped markedly to a value close to that suggested by the distributor (ABS (Pty.) Ltd South Africa) as indicating oestrus. A further insemination was performed if the conductivity dropped to a value lower than that of the previous day, and again when the conductivity began to rise from its lowest value. In any given animal, the first insemination was Mashona semen, the second Hereford and the third, if given, Brahman.

In Group 3, animals all received one cloprostenol injection, after which they were inseminated approximately 12 hours after overt signs of oestrus. Animals that had...
not been inseminated by 10 days after the initial cloprostenol injection received a second injection on the eleventh day, followed by inseminations at 72 and 96 hours. Again, the first insemination was Mashona semen and the second Hereford; third inseminations were not used in this group.

Results and Discussion

The pattern of cervical mucus conductivity readings in Mashona and Afrikaner cows of Group 2, aligned on the lowest reading obtained is shown in Fig. 1. This pattern is similar to that observed by other workers in dairy cows and heifers (Leidl & Stolla, 1976; Schams et al., 1977; Heckman et al., 1979; Foote, Oltenacu, Kummerfeld, Smith, Rick & Braun, 1979). As was observed by Foote et al. (1979) there was no apparent difference between fertile and non-fertile oestrus. Similarly, there were no differences in pattern or levels recorded between the two breeds, whether the oestrus was silent or not (Table 1). There was, however, a tendency for animals to conceive more readily if the lowest reading was below 35 and the decline to and rise from, the nadir was steep. It is suggested that this tendency may not necessarily reflect fundamental differences in fertility, but rather that in those cows which have a less steep descent to a nadir between 40 and 45, it is more difficult for the operator to identify the correct day on which to inseminate. Probing at 12 hour intervals, at or about the nadir, may remove some of the uncertainty associated with the prediction. In this regard it should be noted that it is the pattern of fall of the conductivity readings that is important, and a single low reading in isolation is not sufficient for an accurate prediction. The experience of the operator will therefore be a major factor in obtaining acceptable conception rates with the aid of this instrument.

The conception rates for each of the three groups are broadly comparable to results obtained for beef cows in Zimbabwe, both on research stations (Ward, H.K., personal communication) and by commercial inseminators (Francis, A.B.G., unpublished results) and elsewhere, (Wilson, Benecke, Irvin, Ludwick, Marshall & Wallace, 1979). In the Mashona, the use of the conductivity detector (Group 2) gave an improvement of 7 per cent in conception rate over the Group 3 system and 15 per cent over fixed-time AI. In the Afrikaner a 21 per cent gain was obtained over both fixed-time and the Group 3 system (Table 2).

These results confirm that the conductivity detector can provide at least an equally precise predictor of the optimum time to inseminate as oestrus itself which is further illustrated by the coded semen results for Group 2 (Table 3). By far the higher proportion of animals of both breeds in this group conceived to an insemination performed at the nadir, rather than to inseminations as the conductivity began to rise on the day after the nadir. Furthermore, endocrine activity as determined by a fall in the conductivity readings (Owen, 1978) was recorded in 35 per cent of the Mashona and 23 per cent of the Afrikaner, where no overt signs of oestrus were evident to the observing stockmen. However, short oestrous periods may have occurred during the night in a proportion of these animals.

The distribution of the onset of oestrus behaviour after cloprostenol treatment in this trial (Table 4) corresponds

<p>| Table 2 |
|-------------------------------|------------------|
| Percentage conception and number of inseminations per conception [in parentheses] for all groups |</p>
<table>
<thead>
<tr>
<th>Mashona</th>
<th>Afrikaner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
</tr>
<tr>
<td>2 x PG</td>
<td>AI at 72 and 96 h</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
</tr>
<tr>
<td>2 x PG</td>
<td>AI to 'oestrus' detector</td>
</tr>
<tr>
<td>Group 3</td>
<td></td>
</tr>
<tr>
<td>1 x PG</td>
<td>AI to observed oestrus</td>
</tr>
<tr>
<td>2nd PG</td>
<td>AI at 72 and 96 h</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
</tr>
</tbody>
</table>
**Table 3**

*The percentage of pregnant cows of each breed in Group 2 conceiving to first, second and third inseminations using coded semen*

<table>
<thead>
<tr>
<th>Breed</th>
<th>1st AI</th>
<th>2nd AI</th>
<th>3rd AI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mashona</td>
<td>69</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Afrikaner</td>
<td>83</td>
<td>0</td>
<td>17</td>
</tr>
</tbody>
</table>

1. None of the first AI with Mashona semen were performed on the day prior to lowest reading, nor were any inseminated subsequent to the nadir.

2. None of the second AI with Hereford semen were performed on the day of lowest readings; therefore all were done on the day a rise was perceived after the 1st insemination.

3. All performed on the day when a rise from the nadir was perceived and represent the uncertainty associated with the correct identification of the nadir, and as such are functionally equivalent to the second insemination.

Recent work in dairy cows has shown that the lowest conductivity value corresponds closely to the pre-ovulatory surge of luteinising hormone (LH) (Schams et al., 1977; Owen, 1978) and that the changes in the conductivity of the cervical mucus is in response to changing levels of oestrogen and progesterone in the blood at this time (Owen, 1978).

Various estimates of the time interval from the LH surge to ovulation in cows have been made: 28.7 ± 0.7 h (Christensen, Echternkamp & Laster, 1975), 25.7 ± 6.9 h (Schams et al., 1977). If this interval between the pre-ovulatory LH surge and ovulation (approx. 30 h) is considered in relation to the distribution of lowest conductivity readings shown in Table 4, it follows that some 20 to 30 per cent of ovulations in both breeds will occur later than 120 h after the second PG injection. This value will represent the percentage of animals that may not reasonably be expected to conceive to inseminations at 72 and 96 h after the second PG injection (Group 1). This estimate contrasts with those of Cooper (1974) and Dobson et al. (1975) for dairy herds where possible conceptions to inseminations at 72 and 96 h would approach 95 per cent based on the distribution of observed oestrus.

The conclusion is that two fixed-time inseminations following cloprostenol synchronisation (Group 1) in the Mashona or Afrikaner will not give acceptable conception results, no matter what choice of insemination times is made. To deal with the broad temporal spread of oestrous activity evident in these 2 breeds following cloprostenol treatment, insemination must take place at the physiologically correct moment, to ensure coincidence of sperm and ovum.

**Table 4**

*Percentage distribution of onset of oestrus and lowest conductivity readings following the second PG injection in Group 2 animals*

<table>
<thead>
<tr>
<th>Hours after second PG injection</th>
<th>48 – 72</th>
<th>72 – 96</th>
<th>96 – 120</th>
<th>120 – 144</th>
<th>144 – 168</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oestrus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mashona</td>
<td>24</td>
<td>39</td>
<td>18</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Afrikaner</td>
<td>52</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td><strong>Conductivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mashona</td>
<td>48</td>
<td>17</td>
<td>13</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Afrikaner</td>
<td>46</td>
<td>8</td>
<td>30</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>
Though the results do confirm the close temporal relation of the sharp conductivity dip to oestrus that has been shown previously by Noonan, Schultze & Ellington (1975), Schams et al. (1977) and Foote et al. (1979), this correspondence of oestrus and lowest conductivity is not, however, exact. To illustrate the relation between conductivity and oestrus more precisely, the percentage of cows of the 2 breeds commencing oestrus on the day of lowest conductivity, on days prior to, and following day of lowest conductivity are shown in Fig. 2. The proportion of each class conceiving to an insemination in each class are shown stippled.

This asynchrony between oestrus and lowest conductivity and by extension the pre-ovulatory LH surge, depicted in Fig. 2 would serve to reduce the conception rate in animals inseminated to behavioural oestrus (Group 3) though not to conductivity detector readings (Group 2). On the basis of the present data it is not possible to accurately predict the effect this particular phenomenon may have on conception rate, though the proportion of animals showing a large asynchrony, that is those animals whose lowest conductivity reading was obtained 2 to 3 days prior to onset of oestrus, was 25 per cent of the Mashona and 10 per cent of the Afrikaner. A possible explanation for this phenomenon is that 'threshold' levels of oestrogen are required to trigger LH release and onset of behavioural oestrus, and that the threshold for the release of LH is reached at a relatively early stage causing early ovulation in relation to the onset of oestrus. A similar suggestion has been made by Evans & Robinson (1980) to explain a like phenomenon in sheep. Land, Pelletier, Thimonier & Mauleon (1973) have postulated that in naturally fertile breeds of sheep, the threshold is greater than in less fertile breeds, and it takes longer to build up sufficient oestrogen to trigger LH release and therefore gives a better correspondence between oestrus and ovulation.

In support of this suggestion is the observation from Group 2 animals that 80 per cent of those animals showing mucous discharge and good uterine tone (60 per cent of all animals probed) also exhibited their lowest conductivity at the same time. A high proportion of those animals showing substantial asynchrony is included amongst this 80 per cent. This observation would suggest that in certain animals the oestrogen 'threshold' for manifestation of certain physiological events is reached earlier than that for the full expression of the behavioural components of oestrus.

Further detailed work will be required to resolve the relations between endocrine events and the various physiological and behavioural components of the oestrous period and their effect on conception in beef cows.

Acknowledgements
The authors wish to thank the Animal Breeders Co-op. Co. Ltd., Salisbury, for the loan of the AHD-1 Heat Detector used in this trial.

References

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