S. Afr. J. Anim. Sci. 10, 119 - 124 (1980)

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

Receipt of MS 16-06-1980

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

OPSOMMING: DIE GELEIBAARHEID VAN DIE SERVIKALE MUKUS AS 'N VOORSPELLER VAN OVULASIE BY VLEISBEESKOEIE WAT MET CLOPROSTENOL GESINKRONISEER IS

'n Kommersiele geleibaarheidsmeter is gebruik om die veranderinge in die elektriese geleibaarheid van die servikale mukus van Mashona- en-Afrikanerkoeie wat met cloprostenol gesinkroniseer is, te monitor in 'n poging om die optimale tyd vir kunsmatige inseminasie te voorspel. Geleibaarheids lesings het 'n laagtepunt net voor of tydens bronstigheid bereik; 'n patroon en peile wat ooreengestem het met dié van ander werkers. Geen verskil in patroon of peil van geleibaarheid is tussen rasse of tussen koeie wat beset of nie beset geraak het, waargeneem nie. Daar was ook geen verskille tussen die koeie wat tekens van bronstigheid getoon en dié wat dit nie estrus getoon het nie. Inseminasie tydens die stadium van laagste geleibaarheid na 2 inspuitings van cloprostenol 11 dae na mekaar het 'n hoer besettingsyfer getoon as inseminasie op 'n tydsbasis van 72 en 96 h, naamlik vir die Mashonakoeie 57 teenoor 40 persent en vir die Afrikaners 42 teenoor 19 persent. Inseminasie by waargenome estrus na 'n enkele cloprostenolinspuiting gevolg deur 'n verdere inspuiting of inseminasie op 'n tydsbasis vir dié koeie wat nie op die aanvanklike inspuiting gereageer het nie het 'n gemiddelde besettingsyfer van 50 persent by die Mashona- en 19 persent by die Afrikanerkoeie tot gevolg gehad. Van die koeie wat tydens die laagste geleibaarheids lesing geinsemineer is, het 69 persent van die Mashonas en 83 persent van die Afrikaners beset geraak. Die oorblywendes het beset geraak na inseminering 'n dag na die laagste lesing. Tussen 30 en 40 persent van die koeie van beide rasse het die laagste geleibaarheids lesing op die dag voor bronstigheid gehad. Van hierdie koeie het beset geraak na inseminasie tydens laagste lesing wat mag aandui dat vrugbare ovulasie by sommige koeie aansienlik vroeër as met die aanvang van sigbare estrus plaasvind. Die wye verspreiding in beide aanvang van bronstigheid en laagste geleibaarheids lesings van tussen 48 en 168 h na die tweede sinkroniserende inspuiting sal ook 'n hoe besettingsyfers tussen enige kombinasie van 2 inseminasies, gebaseer op 'n tydsbasis, by hierdie rasse teewerk.

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 Mashona 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 uncertaintities (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 vagino-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, Schallenberger, Hoffman & Karg, 1977; Heckman, Katz, Foote, Olternacu, 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-1 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 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 Afrikaners 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 prostaglandinn $F_{2}\alpha$, 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

Table 1

The lowest conductivity readings recorded in cows associated with silent ovulations and fertile and non-fertile oestrous periods for the two breeds

	Lowest conductivity reading			
	$\bar{x}$	SD	CV%	n
Mashona				
Fertile oestrus	34	9	28	14
Non-fertile oestrus	41	8	19	10
Silent oestrus	33	10	30	7
Afrikaner				
Fertile oestrus	34	7	19	5
Non-fertile oestrus	38	13	34	7
Silent oestrus	38	7	20	3

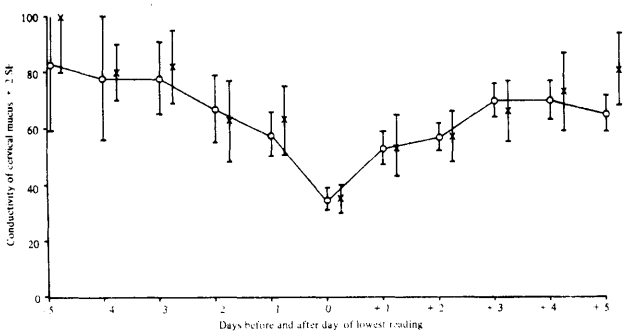

Fig. 1. Conductivity readings of cervical mucus on the day (day 0) of lowest value recorded for Mashona (0) and Afrikaner X, (offset) of cows of Group 2

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

Table 2

Percentage conception and number of inseminations per conception (in parentheses) for all groups

	Mashona	Afrikaner
Group 1		
2 x PG	42 (4,8)	19 (11,0)
AI at 72 and 96 h		
Group 2		
2 x PG	57 (4.0)	40 (5,5)
AI to 'oestrus' detector		
Group 3		
1 x PG	67 (1,7)	43 (2,3)
AI to observed oestrus		
2nd PG		
AI at 72 and 96 h	22 (9,0)	0 (∞)
Overall	50 (2,9)	19 (8,3)

Table 3

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

	1st AI[1]	2nd AI[2]	3rd AI[3]
Mashona	69	16	15
Afrikaner	83	0	17

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.

closely to results obtained in commercial artificial insemination programmes on large numbers of beef animals (> 900) in Zimbabwe (Francis, A.B.G., unpublished results). About 80 per cent of all oestrous activity started between 48 and 120 h after the second cloprostenol injection, a greater temporal spread than that observed by Cooper (1974) and Dobson, Cooper & Furr (1975) who found that 100 per cent of dairy (heifers) commenced oestrous activity during the period 48 to 96 h after the second injection. Similarly, 80 per cent of the lowest conductivity readings were obtained during 48 to 120 h in Group 2 animals.

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 beween 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

	Hours after second PG injection				
	48 – 72	72 – 96	96 – 120	120 – 144	144 – 168
Oestrus					
Mashona	24	39	18	8	11
Afrikaner	52	14	14	14	5
Conductivity					
Mashona	48	17	13	13	9
Afrikaner	46	8	30	8	8

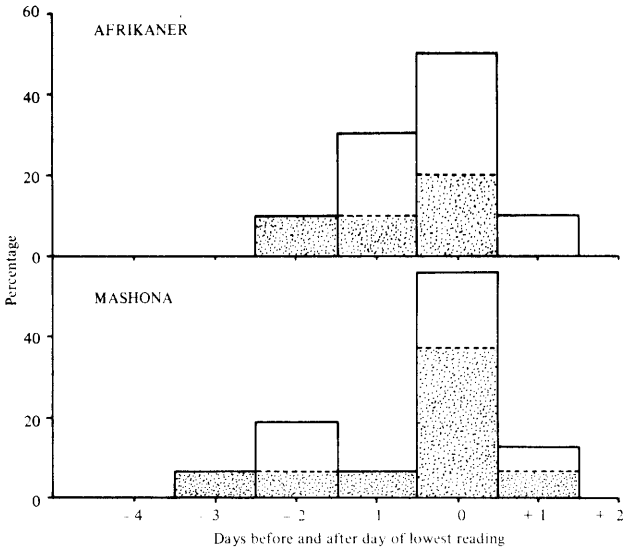

Fig. 2. Percentage of cows in Group 2 showing oestrus on the day of lowest conductivity reading (Day 0), and prior to, and after day of lowest reading. The proportion of cows conceiving to an insemination in each class are shown stippled

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 on the day of lowest conductivity is also shown. Fifty to 60 per cent of animals of both breeds started oestrus and showed lowest conductivity on the same day; between 30 and 40 per cent of both breeds showed their lowest conductivity prior to onset and 10 to 20 per cent the day after the onset of oestrus. It is important to note that some animals conceived to inseminations at the lowest conductivity 48 to 72 h prior, and 24 to 48 h prior to the onset of behavioural oestrus in the Mashona and Afrikaner respectively.

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 behavioural 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.

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