HILL COUNTRY BEEF CATTLE RESEARCH AT WHATAWHATA

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SUMMARY

Experiments on the effects of different planes of nutrition during the last third of pregnancy and the suckling period on the performance of Aberdeen Angus cows and their calves, and of the influences of pre- and post-natal nutrition on the post-weaning growth of heifer calves are described. The total effect at weaning of the pre-calving level of nutrition on calf weaning weight was of similar order to that of the post-calving level of nutrition. Compensatory growth effects progressively reduced the influence of post-natal feeding levels on the post-weaning liveweights of the heifer calves. The influence of low planes of nutrition during late pregnancy on calf mortality and weaning weight were largely avoided by a higher level of feeding during the last eight weeks before calving.

Preliminary observations on a comparison between Friesian and Aberdeen Angus cattle as hill country beef cows are outlined.

A marking device for the detection of oestrous activity in cattle is described.

THE Whatawhata Hill Country Research Station consists of 1,325 acres of land, of which about 1,100 are partly developed. Within this area, integrated experimental flocks of breeding ewes, replacement hoggets, rams, wethers and breeding cows, together with replacement heifers, are carried. Increased topdressing, subdivision, oversowing and higher stocking rates have contributed to increasing the carrying capacity from 3 to 5 ewe equivalents per acre over the 1962–7 period. In general, management techniques are typical of the higher-rainfall North Island hill country. The beef cattle research programme is therefore being conducted within a developing hill country unit and under a high carrying capacity system, since previous management comparisons indicate that important animal (McMeekan and Walshe, 1963; Conway, 1965; Hutton, 1966) and plant differences (Suckling, 1964) can often be distinguished only at higher stocking rates. This policy, as on many hill country farms, appears to be improving pasture production and reducing the proportion of coarse weeds. In consequence, the potential for experiments with classes of cattle other than beef cows and their replacement heifers has been extended.

The overall efficiency of food conversion of single-suckled traditional beef cows appears to be low compared with rapidly-growing cattle or high-fertility sheep (Hutton, 1963; Raymond, 1965). Increasing the efficiency of feeding these breeding herds can be achieved by increasing stocking rate to the extent that individual output is lowered, but per-acre production is increased; by determining the most critical feeding periods and the most suitable feeds and systems of feeding for this class of animal and environment; and by utilizing all available means of improving per-animal productivity. The wintering carrying capacity limits the usefulness of beef cows in developing reverted North Island hill country, compared with the rapid development possible with burning, oversowing, topdressing and concentrated sheep grazing. Furthermore, at stocking rates near 6 ewe equivalents per acre, beef cows may be required to control only limited amounts of excess pasture growth, weeds and shrubs on hill country, and at these stocking rates they tend to compete more with other classes of stock for the available high-quality feed. However, if the high feed costs of beef cows can be reduced during periods of feed shortage, but calf output increased, then the overall efficiency of feeding this class of animal should be improved. These factors, together with the large numbers of breeding cows carried on hill country and the contribution of weaned calves to total beef output have prompted investigations into the effects of various levels of feeding on performance, in particular over the pregnancy and suckling periods. The literature suggests that the efficient winter feeding of mature Aberdeen Angus cows is most likely to occur when the level of feeding is restricted to a point at which there is minimum cow and calf mortality, high calf-growth rates, and unimpaired reproductive performance, particularly when the maximum number of stock are wintered with the minimum of supplementary feed. Where supplements are fed to beef cows at low grazing intensities this can merely result in a substitution of supplements for pasture, less effective foraging activity, and little, if any, overall benefit can be expected (Raymond, 1965; Conway, 1965). Only at higher grazing intensities where a high proportion of the food grown is being utilized, or on poor-quality feeds, is supplementation likely to be useful, and then only during critical periods. The definition of these critical periods with genetically different animals under various feeding and management systems is required.

Initial experiments have been concerned with:

(1) The effects of different levels of nutrition over the late pregnancy and suckling periods on beef cow performance, and of the influence of pre- and post-natal nutrition on post-weaning growth of calves.

(2) Preliminary observations on a comparison between purebred Friesian and Aberdeen Angus cattle as hill country beef cows.

(3) The development of a marking device for detecting the oestrous activity of cattle, and from this information the prediction of accurate calving dates.

These experiments have been evaluated on a per-animal basis in terms of cow liveweights, calf growth and subsequent fertility. The beef herd has been used throughout to assist with development and the control of excess pasture growth. The effects of the various projects in terms of carrying capacity, pasture production and composition, and of the complementary or competitive relationships of breeding cows with other classes of stock, have not been determined.

NUTRITION EXPERIMENTS

Three beef cow nutrition experiments have recently been completed. In the first experiment (Hight, 1966), the effects of a high, in contrast to a very low plane of nutrition in late pregnancy on the performance of hill country beef cows and their calves were studied. In this preliminary project, a reduction of 18% in the liveweight of three- to eight-year-old Aberdeen Angus cows during the last 90 and 83 days, respectively, before calving, reduced calf birthweight from 61 to 49 lb, or by 20%, and calf weaning weight from 298 to 272 lb, or by an age-corrected difference of 36.4 lb. The reduction in birth weight was associated with increased calf mortality. The number of calves present at weaning as a percentage of the number of cows at the start of the experiment was 93% and 75% for the high and low pre-calving treatments, respectively.

In the second nutrition experiment, which involved 140 three- to eight-year-old pregnant Aberdeen Angus cows, the effects of both high (H-) and low (L-) planes of nutrition in late pregnancy, together with high (-H) and low (-L) levels of feeding from calving to weaning, on the performance of beef cows and their calves were studied. Full details of that investigation are published (Hight, 1968a).

The main findings for cow liveweights were that high-plane pre-calving cows (H-H, H-L) gained 58 lb in liveweight, and low-plane pre-calving groups (L-H, L-L) lost 80 lb between their initial liveweight and last pre-calving liveweight. After calving, a corrected difference ot 115 lb ($P<0.001$) in liveweight resulted from the differential pre-calving treatments. Between calving and weaning, the mean cow liveweight gains were 0.84, 0.05, 1.46 and 0.48 lb/day for the H-H, H-L, L-H and L-L groups, respectively, with strong compensatory growth being evident particularly in the L-H group. This general phenomenon of compensatory growth, in which cattle, previously restricted in food intake, rapidly recover in liveweight when food becomes plentiful, in contrast with smaller liveweight gains of animals previously well fed, has been widely recognized (Wilson and Osbourne, 1960; Lawrence and Pearce, 1964) and appears to be of considerable importance in the management of beef cows. Thus the cows on a low plane of nutrition over the pre-calving period gained on average 0.54 lb per day more than high-plane cows during the suckling period. This steadily reduced the pre-calving nutritional effect on cow liveweights to 36 lb ($P<0.05$) at weaning, and to a non-significant difference of 19 lb by April 5, 1966. At weaning, the effect of post-calving plane of nutrition resulted in a 76 lb difference in cow liveweight, but this was reduced to 45 lb ($P<0.01$) on April 5.

The effects of these nutritional treatments on calf growth were that, as in the previous experiment, low-plane feeding until calving reduced birth weight by 13 lb (22%), and there was a higher calf mortality. The number of calves present at weaning at about 130 days of age, as a percentage of the number of cows at the start of the experiment, was 97, 89, 77 and 75% for the H-H, H-L, L-H, and L-L treatments, respectively. These results emphasize the extreme differences in levels of feeding imposed, since the maternal organism is an effective buffer between the environment and the foetus, and it is only when the demands of the dam and the foetus exceed the nutrient intake of the dam plus a labile component from maternal tissue that calf birth weights will be markedly affected (Blaxter, 1957; Lenkeit, 1964). By the time of weaning, the effect of pre-calving plane of nutrition on calf liveweight had increased to an age-adjusted difference of 38 lb ($P<0.001$) and the post calving effect was 36 lb ($P<0.001$). The age-adjusted calf liveweights at weaning for the H-H, H-L and L-H groups were 75, 45 and 44 lb

heavier than those for the L-L group. Hence, in this experiment, the total effect at weaning of the pre-calving level of nutrition on calf weaning weight was similar to that of the post-calving feeding level.

The reduced weaning weight of the low-plane calves attributable to post-calving nutritional level is likely to be due, in part, to a reduced milk yield of their dams (Foot, 1964; Neville, 1962), although no direct measurements were made on this in the present experiment. Pre-calving effects on calf weight are presumably due to carry-over effects on milk production and to direct effects on calf weights. While these differences in calf weaning weights are due to extreme differences in levels of nutrition, the results emphasize the importance of adequate nutrition in late pregnancy and during the suckling period if maximum calf weaning weights are to be obtained. These results also emphasize that when calf weaning weights are used as a criterion of selection in breeding beef cattle, it is necessary to provide a similar pre- and post-natal environment for the whole herd, or these effects must be estimated and allowance made.

The percentage of cows not pregnant, about 200 days after calving, was considerably higher for the L-L group (45%) than for the other three treatments (range 3–9%). As in the first experiment, low-plane feeding in late pregnancy did not affect the subsequent calving percentage if the cows were well fed after calving, although the apparent time of onset of first oestrus and the subsequent calving date were delayed.

To study the possible residual effects of pre- and post-natal levels of nutrition on subsequent liveweight growth, all the heifer calves from this experiment were retained at Whatawhata. They have been grazed as one group or divided into smaller mobs at random for short periods. Mean liveweights of these calves are presented in Fig. 1, for the 16, 15, 10 and 12 heifer calves surviving on September 14, 1967, from the H-H, H-L, L-H, and L-L treatments, respectively. For these animals, there was a corrected and age-adjusted pre-calving effect of 42 ± 17 lb ($P < 0.001$) and a post-calving nutritional effect of 44 ± 7 lb ($P < 0.001$) on calf weaning weight. The pre-calving effect on liveweight was still present by September 14, 1967 and amounted to 33 ± 13 lb ($P < 0.05$) compared with a non-significant difference of 3 ± 13 lb due to the post-calving nutrition effect. However, the higher liveweight gain (408 lb) of the L-L and to a lesser extent of the H-L heifers (384 lb) between weaning and September 14 re-

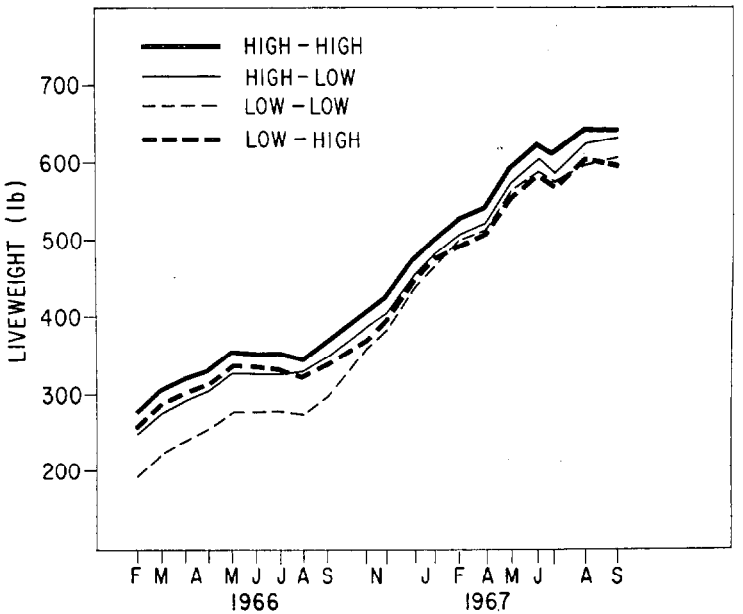

Fig. 1: Pre- and post-natal nutrition and post-weaning growth of heifer calves.

sulted in a 37 ± 12 lb ($P < 0.001$) higher gain in favour of calves fed on a low plane during suckling, but no significant difference in gain due to differences in pre-calving nutrition levels. This indicates that the pre-calving nutritional effect can have a relatively permanent influence on calf liveweight, but that compensatory growth enabled the heifer calves to recover the liveweight difference due to post-calving nutritional levels. This result differs from the first experiment (Hight, 1966) where no residual effect of pre-natal nutritional level on the post-weaning growth of heifer calves was found. However, the higher calf mortality and likely permanency of the pre-calving effect suggests that the influence of nutritional level in late pregnancy could potentially have a greater influence on calf liveweight than the post-calving nutritional effect. This suggests that indexes of the pre-natal nutritional level such as calf birth weight, mortality, and the subsequent calving performance of the cows may be a better guide for defining optimum nutritional levels in

Aberdeen Angus cattle than the maximum weight of calf weaned. Above critical liveweights, additional weight increments of the cow could produce only small differences in current performance, compared with the potentially more efficient system of direct feeding of the calves before and particularly after weaning. This suggestion needs further investigation.

The growth curves also illustrate two apparently general phenomena of the post-weaning growth of hill country heifers. First, poor liveweight gains were achieved between April and September, and, secondly, rapid compensatory growth occurred from then until the following June. While it may be possible to improve the autumn-winter growth rates of young cattle by offering them a wider selection of pastures, as has been demonstrated with young sheep (see Hight and Sinclair, 1967), this can be difficult on a highly-stocked, developing hill country unit, where preferential grazing is usually given to hoggets and breeding ewes. With relatively poor calves at weaning, and this growth check, heifers may not be mated to calve until three years of age, and this is a major inefficiency of the hill country breeding herd.

Some of the undesirable effects observed in the previous experiments, when very low planes of feeding were continued until each cow calved, could be overcome by short periods of higher plane feeding before calving, when foetal demands are at their highest level (Schinckel, 1963; Everitt, 1967) and poor maternal nutrition has the greatest influence on foetal growth and development. Accordingly, a third nutrition experiment (Hight 1968b) which involved 114 four-to eight-year-old Aberdeen Angus cows compared a high level of feeding before calving (H group) with an initial low-feeding level in late pregnancy, but followed by a high level about eight weeks *prepartum* ($L\text{-}H_8$ group) or three weeks *prepartum* ($L\text{-}H_3$ group). All animals were grazed together or in randomly allocated groups on a high feeding level between calving and weaning.

Mean liveweights of the cows relative to calving date are presented in Fig. 2. Mean liveweight changes from May 31 to the last liveweight recorded prior to calving were 0.47, 0.07 and -0.32 lb per day for the H, $L\text{-}H_8$ and $L\text{-}H_3$ treatments, respectively. The H cows weighed, on average, 74 lb more than the $L\text{-}H_3$ animals, and the $L\text{-}H_8$ group were 21 lb heavier than the $L\text{-}H_3$ group immediately after calving. These differences in cow liveweight were steadily reduced during the suckling period, so that by

TABLE 1: COW AND CALF PERFORMANCE: NUTRITION EXPERIMENT, 1966–7

	Treatment			Signif. between Treatments	Corrected Differences ± S.E.	
	H	*L-H₈*	*L-H₃*		*H—L-H₃*	*L-H₈—L-H₃*
Mean birth weight (lb)	61	56	53	***	8.1± 1.8	4.5± 1.7
Mean calf weaning weight (lb)	332	328	317	NS	22 ±14	7 ±13
No. calf/dam pairs	27	32	31			
% calves weaned	91	92	88			
% empty cows at April 4, 1967	0	3	10			

NS: $P>0.005$; ***: $P<0.001$.

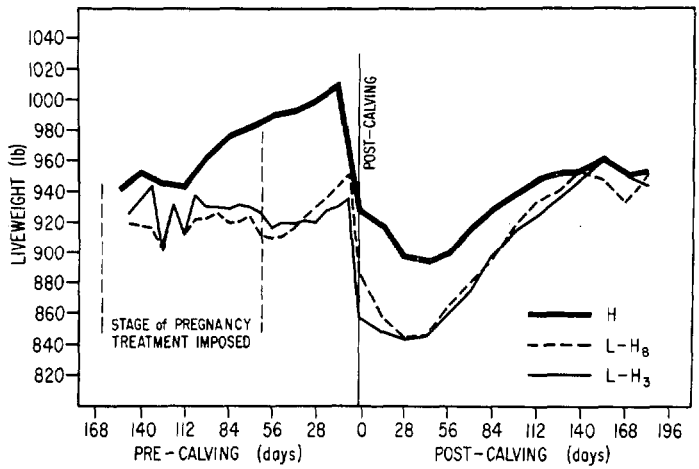

Fig. 2: Cow liveweights relative to calving date (Nutrition experiment, 1966–7).

weaning at about 150 days after calving there were no significant differences between treatment groups.

Some data on cow and calf performance are given in Table 1. Low-plane feeding in late pregnancy until three weeks before calving reduced calf birth weight by a corrected difference of 8.1 lb, and slightly increased calf mortality and the proportion of empty cows the following year. In contrast, only small differences were found between the H and L-H_8 treatments in per-cow performance. No significant differences in calf liveweights between treatments were found at weaning, nor were there any carryover effects of these treatments on the liveweights or gains of the heifer calves between weaning and October 2, 1967. The criteria previously outlined for efficient winter feeding indicate that a system of feeding similar to the L-H_8 treatment could approach the ideal and suggests the possible adjustment in calving dates required to avoid unnecessary supplementary feeding in late winter. Further definition of the critical periods in various feeding and management systems is required.

These data also provided an opportunity to study the carryover effects of the previous year's pre- and post-calving planes of nutrition (Hight, 1968a) on cow performance during the current experiment. It was found that cows that had been on a low plane of nutrition

during the previous suckling period gained more than those that had previously been on a high plane. Similarly, the cows from the low-plane post-calving groups the previous year lost less liveweight on a low plane before calving than those that had been on a high plane. This advantage in growth rate of previously poorly-fed cows amounted to 0.49 lb per day, and was consistent in the H, L-H_8 and L-H_3 groups. Furthermore, the cows previously poorly fed produced calves 6 lb heavier at birth than those that had been well fed over the previous suckling period. The importance of this residual effect could be influenced by the extent of liveweight recovery of the cows after weaning, but it does suggest that cows previously on a lower level of feeding may subsequently be more resistant to undernutrition, or maintain a competitive grazing advantage compared with previously well-fed animals. In practice, this ability of animals to adjust to the feed available could be a useful alternative flexibility to adjusting often costly feed supplies to stock requirements (Coop, 1967). This would be particularly important if the recuperative capacity of mature beef cows to recover from periods of lower planes of nutrition, when subsequently well fed (Bernard and Lalande, 1967), could be utilized to advantage, and in consequence underfeeding near calving could be avoided.

A further nutrition experiment has been conducted with Aberdeen Angus cattle during the 1967–8 season, and this herd has also been used to study the effects of age and weight of calves at weaning on performance. The relatively low calf growth rates between birth and weaning of 1.4, 1.7 and 1.6 lb per day on average, in the three experiments described, suggest that the definition of factors limiting calf growth rate during pre- and postnatal life deserves further study.

COMPARISON BETWEEN FRIESIAN AND ABERDEEN ANGUS CATTLE

The positive relationship between the milk production of the dam and calf growth rate to weaning (Neville, 1962; Brumby *et al.*, 1963), the relatively low calf liveweight gains observed with many single-suckled Aberdeen Angus calves, and the high potential milk production and growth rates of Friesian cattle, suggested that these two breeds should be compared as beef-producing cows on hill country.

TABLE 2: COMPARISON OF FRIESIAN AND ABERDEEN ANGUS HEIFERS

	Friesian	*A. Angus*	*Difference±S.E.*
No. of heifers	22	26	
Mean calving date (days from Jan. 1)	217	243	—26±18**
Mean calf birth weight (lb)	62	56	6±3*
Mean calf weaning weight (lb)	423	310	113±20*** (66±15)***
Mean cow weaning weight (lb)	836	903	—67±29* (—44±21)***

Figures in parentheses—data adjusted for age of calf.
*: $P<0.05$; **$P<0.01$; ***$P<0.001$.

Twenty-two rising two-year-old purebred Friesian dairy heifers, in-calf to Friesian bulls, were purchased from several herds during the autumn of 1966. Thereafter, except over the mating period, they were grazed with 26 purebred rising three-year-old Aberdeen Angus heifers at Whatawhata, and their production compared. A summary of their performance during the 1966–7 season is presented in Table 2. The Friesians calved on average 26 days earlier, and produced calves weighing 62 lb at birth compared with the 56 lb calves born to the Aberdeen Angus heifers. Two calves from each breed group died before weaning. By weaning, on January 31, 1967, the Friesian calves were 113 lb, or, when age corrected, 66 lb ($P<0.001$) heavier than the Aberdeen Angus calves. The younger and earlier calving Friesian cows gained less liveweight between November 8 and weaning than did the Aberdeen Angus, but the Friesians subsequently gained more, so that their post-calving liveweight was of the order of 890 lb compared with 870 lb for the Aberdeen Angus cows after calving in 1967. No fertility or udder problems were encountered with the single-suckled Friesian cows. Their high potential milk production appears to adjust to the feed supply and the calf's capacity.

Nine heifer calves from each of the two breeds have been retained at the Hill Station. Their liveweight growth rates are shown in Fig. 3. The age-corrected advantage of 115 lb ($P<0.001$) in weaning weight of the Friesian heifer calves decreased to 79±13 lb ($P<0.001$) on March 7, 1967, but subsequently increased to 100±16 lb ($P<0.001$) by October 2, 1967. These data indicate that the liveweight

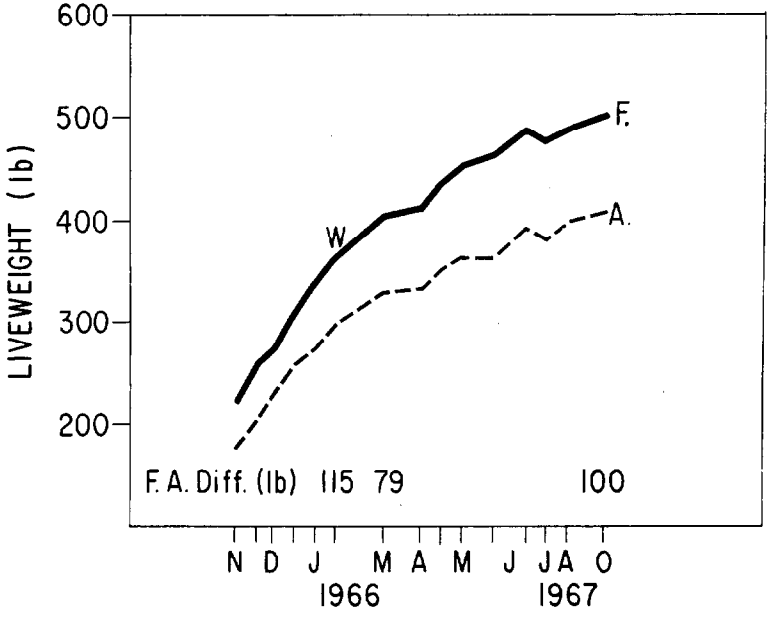

Fig. 3: Liveweight growth of Friesian (F) and Aberdeen Angus (A) heifer calves. W is time of weaning.

advantage of the Friesian heifer calves is maintained over the post-calving period.

Both the Friesian and Aberdeen Angus herds have been increased during the 1967–8 season by the purchase of twenty-one rising two-year-old Friesian heifers, and 18 rising three-year-old Aberdeen Angus heifers reared at the Hill Station. Fourteen of the Friesians have suckled two Friesian calves. During the 1967 season, calving dates were similar in the two breeds, but the Friesian calves born at the Hill Station weighed 66 lb at birth compared with 51 lb for the Aberdeen Angus calves.

Although comparisons would be valid only if all cattle had been reared in a common environment, it is considered that the transfer to a harder environment of the younger Friesians would tend initially to operate against this breed's performance. These preliminary results, therefore, indicate that the purebred Friesian could be superior to the Aberdeen Angus as a beef-producing cow on hill country. The higher weaning weight, good growth

rates, later maturity, potential for multiple suckling, likely absence of large genetic correlations between milk and beef characters, docile temperament and the ability of the Friesian cow to forage actively and show recuperative capacity on hill country, could indicate a considerable potential for increasing the efficiency of hill country beef herds.

A trial has now been initiated to compare the offspring of purebred Friesian and Aberdeen Angus cattle and of their reciprocal crosses in terms of growth rate and carcass composition.

DETECTION OF OESTRUS

One difficulty in conducting nutritional experiments on hill country beef cows has been the absence of precise mating and calving dates. A marking device which appears to meet the special requirements of detecting the oestrous activity of cattle has recently been developed at Whatawhata (Lang *et al.*, 1968) This equipment consists essentially of a ball-bearing revolving within a stainless steel container which contains a marking substance. This is fitted on a halter and attached to the underside of the bull's jaw. During mating the bull invariably rubs his head along the back, sides or rump of the female. This contact rotates the exposed ball-bearing, leaving clear streak marks of the marker on the female, and visible at considerable distances. The most effective marker tested to date is neon ink (Coates Bros. Ltd., Auckland). This is a slow-drying, adhesive, oil-based paint obtainable in a number of iridescent colours. This type of device will be used in studies on oestrous activity in heifers and cows; it may be useful in the detection of cattle for artificial insemination, and from information on oestrus assist in the early detection of conception and the prediction of calving dates.

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