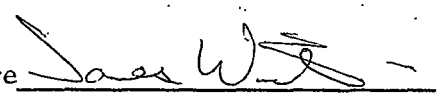
MONTANA STATE UNIVERSITY

Induced calving in beef production
by James Larry Winter

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Animal Science
Montana State University
© Copyright by James Larry Winter (1974)

Abstract:
Eighty-six 2-year-old heifers and 76 aged cows in the fall of 1972 and 30 2-year-old heifers and 275 aged cows in the fall of 1973 were assigned to trials and treatments to determine the effects of corticosteroid induced parturition on cow and calf performance. All animals were part of the Montana State Prison fall calving beef herd and were managed according to usual open range procedures for western range beef production. Three trials consisting of three treatments per trial (1 control and 2 dexamethasone treated) were run in the fall of 1972. The objective of these trials was not only to determine the effects of induced parturition on cow and calf performance, but also to determine if the method of injection of the dexamethasone (intravenously vs. intramuscularly) and/or an increase from one dose to two doses given at a 24 hr interval would result in a reduction in retained placenta and/or an increase in induction success. In the fall of 1973, an induction schedule was developed to divide the 45 day natural calving period of the 275 aged cows into 4 separate induction trials approximately 10 days apart. Each trial consisted of 3 treatment groups (a control and 2 flumethasone treatments). Approximately one-third of the cows were calved as noninduced controls while the other two-thirds were injected with flumethasone to induce parturition. Treated cows in the fall of 1973 were injected between 265-285 days of gestation with 285 days considered normal gestation length. The heifers in the fall 1973 study were assigned to 2 trials having a control and a flumethasone treated group in each trial. Parturition was successfully induced in a high percentage of all cows treated in both years of the study. Heifers and cows responded similarly to the two corticosteroids. Parturition took place on an average of 45-50 hrs after the injection of corticosteroid. In the 1972 study, the methods of induction showed no differences as to retained placenta or induction success. Overall an increase in retained placenta was found in the induced cows over controls in all trials. No decrease in calf vigor at parturition was found in any of the trials. The control cows required 51 days to complete calving compared to 35 days for the flumethasone treated animals in the fall 1973 study. Induced animals generally showed significantly earlier birth dates, shorter gestation lengths and lower birth weights of their calves than the controls in the fall 1973 study. More calving difficulty was found in the induced animals than the controls in certain trials even though birth weight was decreased. General cow health was not affected by the induction treatments, and no differences were found in subsequent fertility when pregnancy rate after a 45 day breeding season and fertility score for the first 25 days of breeding were comparted between groups. Furthermore, subsequent calf performance was not significantly affected by the induction treatments.

In presenting this thesis in partial fulfillment of the requirements for an advanced degree of Montana State University, I agree that the Library shall make it freely available for inspection. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by my major professor, or, in his absence, by the Director of Libraries. It is understood that any copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Signature 

Date 5/29/74

INDUCED CALVING IN BEEF PRODUCTION

by

JAMES LARRY WINTER

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE

in

Animal Science

Approved:

R V Blackwell
Head, Major Department

E L Moody
Chairman, Examining Committee

Henry L Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

June, 1974

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to Dr. E. L. Moody for his advice, assistance and guidance throughout my graduate program. Also, appreciation is extended to Drs. P. J. Burfening, D. D. Kress and R. A. Bellows for their advice and suggestions in preparing this manuscript. Further appreciation is extended to Mr. R. L. Friedrich and Dr. E. P. Smith for their assistance with the computer programming.

A special word of appreciation is due to Verne LaVoie and Greg Poncelet for their countless hours of time spent assisting me in collecting and handling the data.

I would also like to thank the Montana State Prison for the use of their animals and facilities.

Furthermore, my sincere gratitude is expressed to Mrs. Frankie Larson for typing this manuscript.

A very special appreciation is extended to my wife for her help and encouragement during this project.

TABLE OF CONTENTS

	Page
VITA	ii
ACKNOWLEDGEMENTS	iii
INDEX TO TABLES	vi
INDEX TO FIGURES	x
INDEX TO APPENDIX TABLES	xii
ABSTRACT	xvi
INTRODUCTION	1
REVIEW OF LITERATURE	2
Parturition	2
General	2
Ovine	4
Bovine	9
Induction of Parturition	13
General	13
Response	16
Rational for use	28
MATERIALS AND METHODS	30
Fall calving 1972	30
Fall calving 1973	35
RESULTS	46
Fall calving 1972	46
Fall calving 1973	54
DISCUSSION	101
Fall calving 1972	101
Fall calving 1973	105

Page

SUMMARY 121

APPENDIX. 124

LIBERATURE CITED. 154

INDEX TO TABLES

Table		Page
1.	HORMONALLY INDUCED TERMINATION OF GESTATION IN CATTLE (ADAPTED FROM JÖCHLE, 1973; LAMOND et al., 1973; ZEROBIN et al., 1973).	15
2.	CORTOCOSTEROID-INDUCED PARTURITION IN THE BOVINE; COMPOUNDS USED AND DOSE LEVELS OF EFFICACIOUS COMPOUNDS (ADAPTED FROM JÖCHLE, 1973).	21
3.	DATA FROM COWS WHICH WERE TREATED IN THE FIRST AND SECOND TRIALS, BUT DID NOT INDUCE.	33
4.	EFFECT OF DEXAMETHASONE (DEX) GIVEN IN A SINGLE DOSE INTRAMUSCULARLY (I.M) VS. INTRAVENOUSLY (I.V.) ON HEIFERS AND CALVES THAT RESPONDED TO TREATMENT (TRIAL 1)	47
5.	EFFECT OF DEXAMETHASONE (DEX) GIVEN IN TWO INJECTIONS OF DIFFERENT TOTAL DOSAGE AT A 24 HOUR INTERVAL ON HEIFERS AND CALVES THAT RESPONDED TO TREATMENT (TRIAL 2)	48
6.	EFFECT OF DEXAMETHASONE (DEX) GIVEN IN TWO INJECTIONS OF DIFFERENT TOTAL DOSAGE AT A 24 HOUR INTERVAL ON COWS AND CALVES THAT RESPONDED TO TREATMENT (TRIAL 3).	49
7.	SUBSEQUENT FERTILITY OF INDUCED HEIFERS RECEIVING A SINGLE DOSE OF DEXAMETHASONE (DEX) GIVEN INTRA-MUSCULARLY (I.M.) VS. INTRAVENOUSLY (I.V.) (TRIAL 1) . . .	51
8.	SUBSEQUENT FERTILITY OF INDUCED HEIFERS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL (TRIAL 2)	51
9.	SUBSEQUENT FERTILITY OF LATE CALVING AGED COWS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL (TRIAL 3)	52
10.	SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS RECEIVING A SINGLE DOSE OF DEXAMETHASONE (DEX) GIVEN INTRAMUSCULARLY (I.M.) VS. INTRAVENOUSLY (I.V.) TRIAL 1)	53

Table Page

11. SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL (TRIAL 2). 55

12. SUBSEQUENT PERFORMANCE OF CALVES FROM LATE CALVING AGED COWS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL (TRIAL 3) 56

13. EFFECT OF FLUMETHASONE (FLU) GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES AT PARTURITION (TRIAL 11) 57

14. EFFECT OF FLUMETHASONE (FLU) GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (TRIAL 11). 59

15. EFFECT OF FLUMETHASONE GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE (FLU) GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES AT PARTURITION (TRIAL 12) . . . 60

16. EFFECTS OF FLUMETHASONE (FLU) GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (TRIAL 12) . . . 62

17. EFFECTS OF TWO DOSE LEVELS OF FLUMETHASONE (FLU) ON COWS AND CALVES AT PARTURITION (TRIAL 13). 64

18. EFFECTS OF TWO DOSE LEVELS OF FLUMETHASONE (FLU) ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (TRIAL 13) 65

19. EFFECT OF A.M. VS. P.M. INJECTION OF FLUMETHASONE (FLU) ON COWS AND CALVES AT PARTURITION (TRIAL 14) . . . 67

20. EFFECT OF AN A.M. VS. P. M. INJECTION OF FLUMETHASONE (FLU) ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (TRIAL 14). 68

Table Page

21. NUMBER OF CALVINGS OBSERVED DURING THE DAY OR NIGHT AFTER INDUCTION OF PARTURITION WITH 10 MG FLUMETHASONE IN CATTLE 70

22. EFFECT OF FLUMETHASONE (FLU) ON TWO-YEAR-OLD HEIFERS AND CALVES AT PARTURITION (TRIAL 15) 71

23. EFFECT OF FLUMETHASONE (FLU) ON TWO-YEAR-OLD HEIFERS AND CALVES AT PARTURITION (TRIAL 16) 72

24. EFFECT OF FLUMETHASONE (FLU) ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (TRIALS 11-14) 75

25. EFFECT OF FLUMETHASONE ON COWS AND CALVES IN TRIALS 11-12 THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (CONTROLS EXCLUDED) 76

26. EFFECT OF GESTATION LENGTH ON INDUCTION SUCCESS IN COWS TREATED WITH FLUMETHASONE FOR EARLY PARTURITION (CONTROLS NOT INCLUDED). 81

27. EFFECT OF FLUMETHAZONE ON COWS AND CALVES IN TRIALS 11-14 THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (CONTROLS EXCLUDED). 89

28. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) IN A SINGLE INJECTION VS. FLUMETHASONE IN TWO INJECTIONS 12 HOURS APART (TRIAL 11) 91

29. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) IN A SINGLE INJECTION VS. FLUMETHASONE IN TWO INJECTIONS 12 HOURS APART (TRIAL 12) 92

30. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) AT TWO DIFFERENT DOSE LEVELS (TRIAL 13). 93

31. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) IN AN A.M. INJECTION VS. P.M. INJECTION (TRIAL 14) 94

32. SUBSEQUENT FERTILITY OF HEIFERS RECEIVING FLUMETHASONE (FLU) (TRIAL 15) 96

Table | Page

34. SUBSEQUENT FERTILITY OF ALL COWS RESPONDING TO TREATMENT WITH FLUMETHASONE (FLU) TRIALS 11-14) 97

35. EFFECT OF GESTATION LENGTH AT TIME OF PARTURITION AND RETENTION OF PLACENTAL MEMBRANES AT 24 HOURS AND 1 WEEK AFTER PARTURITION ON SUBSEQUENT FERTILITY OF COWS SUCCESSFULLY TREATED WITH FLUMETHASONE. 99

INDEX TO FIGURES

Figures		Page
1.	Proposed model of the mechanism controlling the initiation of parturition in the ewe. (Liggins et al., 1973)	8
2.	Schedule of induced calving season as compared to projected length of normal calving season in trials 11-14.	37
3.	Length of induced calving season as compared to actual length of normal calving season in trials 11-14	74
4.	Partial regression of calf vigor score on gestation length at time of injection in cows successfully treated with flumethasone in trials 11-12	78
5.	Partial regression of retained placenta at 24 hrs on gestation length at injection in cows successfully treated with flumethasone in trials 11-12	79
6.	Partial regression of retained placenta at 1 week on gestation length at injection in cows successfully treated with flumethasone in trials 11-12	80
7.	Partial regression of induction success on gestation length at injection in cows successfully treated with flumethasone in trials 11-12	82
8.	Partial regression of birth weight on gestation length at injection in cows successfully treated with flumethasone in trials 11-14	84
9.	Partial regression of hours from induction to parturition on gestation length at injection in cows successfully treated in trials 11-14	85
10.	Partial regression of calf vigor score on gestation length at time of injection in cows successfully treated with flumethasone in trials 11-14	86

Figure Page

11. Partial regression of retained placenta at 24 hrs on gestation length at injection in cows successfully treated with flumethasone in trials 11-14 87

12. Partial regression of induction success on gestation length at injection in cows successfully treated with flumethasone in trials 11-14 88

INDEX TO APPENDIX TABLES

Table		Page
1.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN TWO-YEAR-OLD HEIFERS AND CALVES AFTER TREATMENT WITH DEXAMETHASONE (TRIAL 1)	125
2.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN TWO-YEAR-OLD HEIFERS AND CALVES THAT RESPONDED TO TREATMENT WITH DEXAMETHASONE (TRIAL 2). . .	125
3.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH DEXAMETHASONE (TRIAL 3)	126
4.	LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY AND FERTILITY SCORE IN HEIFERS SUCCESSFULLY TREATED WITH FLUMETHASONE (TRIAL 1).	126
5.	LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY AND FERTILITY SCORE IN HEIFERS SUCCESSFULLY TREATED WITH FLUMETHASONE (TRIAL 2).	127
6.	LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY AND FERTILITY SCORE IN COWS SUCCESSFULLY TREATED WITH FLUMETHASONE (TRIAL 3).	127
7.	LEAST SQUARES ANALYSIS OF VARIANCE FOR SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS SUCCESSFULLY TREATED WITH DEXAMETHASONE (TRIAL 1)	128
8.	LEAST SQUARES ANALYSIS OF VARIANCE FOR SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS SUCCESSFULLY TREATED WITH DEXAMETHASONE (TRIAL 2)	128
9.	LEAST SQUARES ANALYSIS OF VARIANCE FOR SUBSEQUENT PERFORMANCE OF CALVES FROM COWS SUCCESSFULLY TREATED WITH DEXAMETHASONE (TRIAL 3).	129
10.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 11)	130

Table Page

11. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 11) 131

12. LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INJECTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 11). 132

13. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS AFTER TREATMENT WITH FLUMETHASONE (TRIAL 11) 133

14. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 12). 134

15. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 12) 135

16. LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INJECTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 12) 136

17. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 12). 136

18. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 13) 137

19. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 13). 138

20. LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INJECTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 13). 139

21. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS AFTER TREATMENT WITH FLUMETHASONE (TRIAL 13) 139

Table		Page
22.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 14)	140
23.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 14).	141
24.	LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INDUCTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 14).	142
25.	LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS AFTER TREATMENT WITH FLUMETHASONE (TRIAL 14).	142
26.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN HEIFERS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 15)	143
27.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN HEIFERS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 16)	144
28.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES RESPONDING TO TREATMENT WITH FLUMETHASONE (TRIAL 11-14)	145
29.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO THE TREATMENT OF FLUMETHASONE IN TRIALS 11 AND 12 (CONTROLS EXCLUDED)	146
30.	LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN FLUMETHASONE TREATED COWS (CONTROLS EXCLUDED)	147
31.	LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED SUCCESSFULLY TO TREATMENT WITH FLUMETHASONE IN TRIALS 11-14 (CONTROLS EXCLUDED)	148

Table | Page

32. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRIAL 11) 149

33. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRIAL 12) 149

34. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRIAL 13) 150

35. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRIAL 14) 150

36. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN HEIFERS TREATED WITH FLUMETHASONE (TRIAL 15) 151

37. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN HEIFERS TREATED WITH FLUMETHASONE (TRIAL 16) 151

38. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN ALL COWS RESPONDING TO TREATMENT WITH FLUMETHASONE (TRIALS 11-14) 152

39. LEAST SQUARES ANALYSIS OF VARIANCE FOR GESTATION LENGTH AT TIME OF PARTURITION AND RETENTION OF PLACENTAL MEMBRANES AT 24 HOURS AND ONE WEEK AFTER PARTURITION IN COWS SUCCESSFULLY TREATED WITH FLUMETHASONE 153

ABSTRACT

Eighty-six 2-year-old heifers and 76 aged cows in the fall of 1972 and 30 2-year-old heifers and 275 aged cows in the fall of 1973 were assigned to trials and treatments to determine the effects of corticosteroid induced parturition on cow and calf performance. All animals were part of the Montana State Prison fall calving beef herd and were managed according to usual open range procedures for western range beef production. Three trials consisting of three treatments per trial (1 control and 2 dexamethasone treated) were run in the fall of 1972. The objective of these trials was not only to determine the effects of induced parturition on cow and calf performance, but also to determine if the method of injection of the dexamethasone (intravenously vs. intramuscularly) and/or an increase from one dose to two doses given at a 24 hr interval would result in a reduction in retained placenta and/or an increase in induction success. In the fall of 1973, an induction schedule was developed to divide the 45 day natural calving period of the 275 aged cows into 4 separate induction trials approximately 10 days apart. Each trial consisted of 3 treatment groups (a control and 2 flumethasone treatments). Approximately one-third of the cows were calved as noninduced controls while the other two-thirds were injected with flumethasone to induce parturition. Treated cows in the fall of 1973 were injected between 265-285 days of gestation with 285 days considered normal gestation length. The heifers in the fall 1973 study were assigned to 2 trials having a control and a flumethasone treated group in each trial. Parturition was successfully induced in a high percentage of all cows treated in both years of the study. Heifers and cows responded similarly to the two corticosteroids. Parturition took place on an average of 45-50 hrs after the injection of corticosteroid. In the 1972 study, the methods of induction showed no differences as to retained placenta or induction success. Overall an increase in retained placenta was found in the induced cows over controls in all trials. No decrease in calf vigor at parturition was found in any of the trials. The control cows required 51 days to complete calving compared to 35 days for the flumethasone treated animals in the fall 1973 study. Induced animals generally showed significantly earlier birth dates, shorter gestation lengths and lower birth weights of their calves than the controls in the fall 1973 study. More calving difficulty was found in the induced animals than the controls in certain trials even though birth weight was decreased. General cow health was not affected by the induction treatments, and no differences were found in subsequent fertility when pregnancy rate after a 45 day breeding season and fertility score for the first 25 days of breeding were comparted between groups. Furthermore, subsequent calf performance was not significantly affected by the induction treatments.

INTRODUCTION

In the late 1960's, various investigators reported that corticosteroid containing compounds would cause precocious or premature parturition in cattle if injected in the third trimester of pregnancy. Moreover, it has been determined that parturition can be induced within a certain predetermined time when corticosteroids are used at recommended levels.

Calving time is one of the most important times of the year for a livestock producer. Depending on the management at calving a producer can encounter calf losses as low as 0 to 4% or as high as 14 to 100%. A good management system at calving involves 24-hour observation of cows during the entire calving season; not neglecting cows which calve prior to the expected start of calving or those which calve after the estimated end of calving. Obviously, this type of management requires many man hours of qualified labor. However, if calving could be controlled so cows calved at a predetermined time, one might conserve a considerable amount of labor.

The purpose of the present study was to evaluate the effects of corticosteroid-induced parturition on beef production when used under field conditions and to develop a possible management system for calving utilizing induced parturition. The effects on beef production were evaluated by looking at cow and calf performance at calving, subsequent calf performance and subsequent reproductive performance of the cows.

REVIEW OF LITERATURE

Parturition

General. Several hundred years ago Hippocrates suggested that the fetus pushed itself out of the uterus when food stores became depleted. This theory concerning the fetus giving off the signal for the start of parturition was not well accepted in years gone past. Most scientists felt that the maternal organism through her endocrine system terminated pregnancy (Catchpole, 1969; Schofield, 1968). However, Liggins, Kennedy, and Holm (1967) performed a series of elegant studies of the fetal pituitary function in sheep which supported the possibility of fetal factors being important in labor. This work was precipitated by the fact that prolonged pregnancy in various animals had been linked to congenital deformities of the fetus (Lanman, 1968). In one such study, Binns et al. (1960) described a syndrome of prolonged pregnancy in sheep carrying lambs congenitally deformed by a teratogenic agent found in a weed which caused deformities of the fetal endocrine glands. It was found that prolonged pregnancy only occurred when all fetal lambs were afflicted with the condition. Huston and Grier (1958) concluded that prolonged gestation in some hydrocephalic calves was caused because of an endocrine abnormality in the fetus. This abnormality was reported to be aplasia of the fetal adenohypophyses. Jafar, Chapman and Casida (1950) estimated that the genotype of the calf, within sex, and the permanent maternal characteristics were responsible for 48 and 21% of the variation in gestation length, respectively.

DeFries, Touchberry and Hay (1959) showed that in their studies the heritability of gestation length, considered as a character of the fetus alone, was 0.420, and considered as a combined characteristic of fetus and dam it was very little more, 0.474. They concluded that gestation length was primarily determined by the calf.

Liggins et al. (1967) hypophysectomized fetal lambs and caused an indefinite prolongation of pregnancy. Comline et al. (1970) confirmed the work of Liggins by prolonging gestation by hypophysectomy of fetal lambs. In another study a stalk section in five fetal lambs at 111-126 days of gestation caused prolonged gestation (Liggins and Kennedy, 1968). Holm, Parker and Galligan (1961) postulated that, among ruminants the fetal adrenal is a major determinant in the initiation of labor. Bilateral adrenalectomies were performed on lamb fetuses, and caused delivery 10 days or more beyond term (Drost and Holm, 1968). Liggins (1968) infused ACTH daily into fetal lambs of more than 88 days gestional age causing parturition on day 4 to day 7 of infusion. At birth, the fetal adrenals weighed at least as much as those of normal lambs at term (Liggins, 1968). An increased level of secretion of corticosteroids was evident by the elevated levels of cortisol, and the evidence of the biological action of cortisol (Liggins, 1968). Thorburn et al. (1972) demonstrated that the infusion of synthetic ACTH into the goat fetus induced premature parturition preceded by a marked increase in the concentration of corticosteroids in the fetal plasma. Liggins (1968) infused cortisol into the ovine fetus at a rate of 50 mg/24 hrs;

parturition took place within 5 days. In another study, Liggins (1969) caused premature delivery when glucocorticoids were infused into the ovine fetus. No effect was found when compounds with mineralocorticoid activity were infused into the fetus in the above experiment. These observations suggest that normal parturition in the goat and sheep (Liggins and Kennedy, 1968; Liggins, 1969; Liggens et al., 1973; Bassett and Thurnburn, 1969) is triggered by activation of the pituitary-adrenal axis of the fetus.

Lanman and Schaffer (1968) decapitated fetal lambs in utero; of the three fetuses that survived, two were delivered spontaneously at term, while the third had not initiated parturition by 25 days post term. All three lambs had very small adrenals when lambed, and the two lambs delivered near term could have possibly died before parturition. In rats, removal of the fetuses with the placentas left intact at any time from the fourteenth to the twenty-first day of pregnancy has led to delivery of the retained placentas at normal term (Kirsch, 1938), and similar observations have been made in monkeys (Van Wagene and Newton, 1949). The above studies give some doubt to the hypothesis of Liggins et al. (1973).

Ovine. The major site of progesterone production in the ewe in late pregnancy is the placenta (Linzell and Heap, 1968; Thorburn and Mathner, 1971). The concentration of progesterone in peripheral blood falls during the last few days of pregnancy in the ewe (Bassett et al., 1969; Fylling, 1968, 1970; Thornburn et al., 1972; Chamley et al.,

1973) to a low level on the day of parturition. Short and Rowell (1962) showed that the metabolic clearance rate of progesterone does not change in late pregnancy so a decrease in blood progesterone levels represents diminishing secretion. Total unconjugated estrogens, on the other hand, increase significantly 16-24 hrs prior to parturition in the ewe (Challis, 1971; Obst and Seamark, 1972a; Thorburn et al., 1972; Chamley et al., 1973). Robertson and Smeaton (1973) clearly revealed that a dramatic increase in the concentration of unconjugated estrone, estradiol-17α and estradiol-17β occurs in the jugular venous plasma of the pregnant ewe beginning at about 40 hrs before parturition and reaching a peak of parturition. These workers demonstrated that the concentrations of estradiol-17α and estradiol-17β are very similar and are approximately half that of the concentration of estrone. Liggins et al. (1973) felt that not enough evidence has been accumulated to determine the source of unconjugated estrogens which suddenly appear. However, Challis et al. (1971) and Bedford et al. (1972) demonstrated that the probable source of the estrogens is the conceptus. Chamley et al. (1973) reported a substantial increase in maternal corticosteroid levels beginning 6-18 hrs before birth. An increase in maternal plasma corticosteroid levels at parturition was also observed by Obst and Seamark (1972b) while Bassett and Thorburn (1969) reported no increase. Prostaglandin $F_2\alpha$ is one other hormone which is felt to have a physiological role in the mechanism controlling labor (Liggins et al., 1972; Liggins, 1973). In sheep, an increase in

the concentration of $PGF_{2\alpha}$ in the maternal placenta precedes the onset of labor by at least 24 hrs (Liggins and Grieves, 1971). Thorburn et al. (1972) found that $PGF_{2\alpha}$ concentrations increased in uterine venous blood preceding labor.

Bosc (1972) hypophysectomized pregnant ewes at day 50-134 and observed normal parturition, hence, Liggins et al. (1973) theorizes very little importance of the hormones from the maternal anterior pituitary in parturition. However, levels of hormones from the anterior pituitary are of interest. Chamley et al. (1973) found no observable change in LH during parturition. Furthermore, they did find a sharp increase in prolactin starting at about 2 days before parturition with highest levels being found shortly before parturition in most animals. These data were consistent with that of Davis, Reichert and Niswender (1971) and Fell et al. (1972).

Many scientists assume that oxytocin from the maternal pituitary plays an important role in the initiation and maintenance of labor (Fuchs, 1971; Chard, 1972). However, in a review of the role of oxytocin in parturition, Chard (1972) found evidence of an abrupt release of oxytocin at the time of delivery and not earlier in the ovine. Chard (1972) felt that if this release has a function, it must be to expedite the process of delivery itself, and it is unlikely that oxytocin is responsible for the initiation of labor.

In the ovine fetus, a rapid increase in adrenal weight is found in the last week of gestation (Comline and Silver, 1961).

Nathanielsz et al. (1972) confirmed these data by showing a marked rise in adrenal weight during gestation starting 10 days before birth. Nathanielsz et al. (1972) observed that this growth takes place primarily in the adrenal cortex. This adrenal growth is paralleled by marked increases in the plasma corticosteroid concentration of the fetus (Bassett and Thorburn, 1969; Bassett, Thorburn and Nicol, 1973; Nathanielsz et al., 1972; Alexander et al., 1968) and an increase in corticosteroid turnover rate (Comline et al., 1970). Also an increase in ACTH was found at this time (Alexander et al., 1971). Liggins et al. (1973) found a sharp rise in cortisol levels in fetal plasma starting on day 4 prepartum with high levels 48 hrs prior to parturition. The transfer of cortisol across the placenta in either direction is relatively small but increases near term (Liggins et al., 1973). Findlay and Cox (1970) showed a high level of estrogen sulphates in fetal plasma, but no rise in fetal unconjugated estrogen at time of parturition has been reported (Thorburn et al. 1972). The fetal adrenal has also been shown to produce precursors for estrogen production of the placenta (Van Kampen and Ellis, 1972; Findlay and Semark, 1971).

With the information available at the present time, Liggins (1972) and Liggins et al. (1973) have proposed that the stimulus to parturition in the ewe originates in the fetal hypothalmus (Figure 1). However, the actual factors influencing hypothalamic activity and determining the timing of the mechanism remain uncertain. Liggins et al. (1973) has

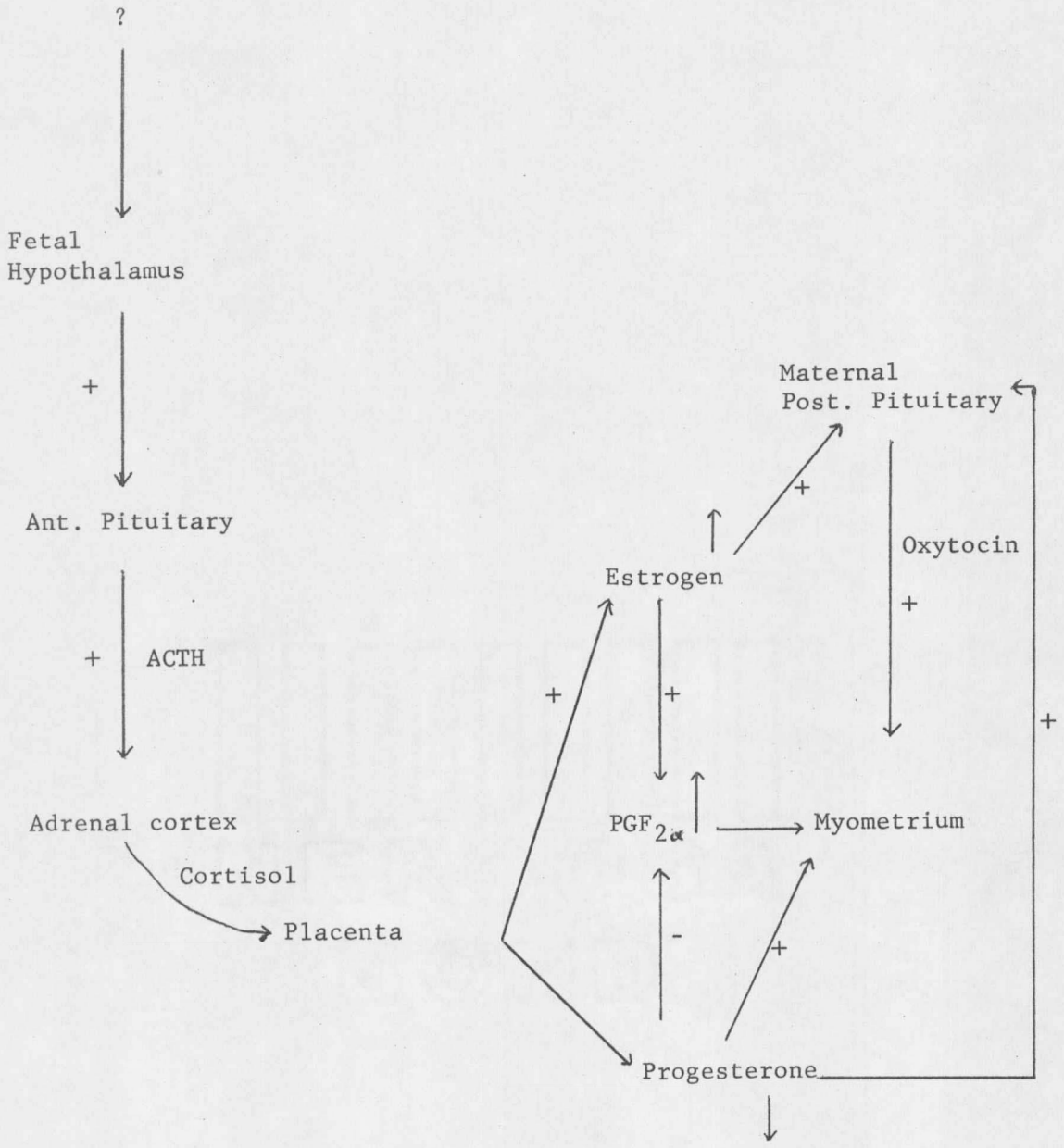


Figure 1. Proposed model of the mechanism controlling the initiation of parturition in the ewe. (Liggins et al., 1973)

summarized his theory of the mechanism of parturition in the ewe:

> As a result of hypothalamic and pituitary activity, the rate of secretion of cortisol increases rapidly owing to the combined effects of cortical growth, of activation of the enzyme 11β-hydroxylase, and of increased responsiveness of the adrenal cortex to ACTH.
>
> Cortisol in relatively high concentrations in the fetal blood acts on the placenta by unknown mechanisms to reduce the secretion of progesterone and to increase the secretion of estrogen. Simultaneously, greater production of androgen by the fetal adrenal cortex may promote estrogen synthesis in the placenta. Associated with a rising concentration of unconjugated estrogen - and probably induced by it - is an equally sharp increase in the concentration of $PGF_{2\alpha}$ in maternal cotyledons and myometrium. At the same time the concentration of $PGF_{2\alpha}$ in uterine venous blood is elevated.
>
> The myometrium responds to $PGF_{2\alpha}$ with heightened sensitivity to oxytocin, which may permit unchanged levels of circulating oxytocin to induce uterine contractions. It is uncertain in the sheep whether $PGF_{2\alpha}$ itself has a direct oxytocic action.
>
> Finally, distension of the cervix and vagina by descent of the fetus reflexly stimulates release of oxytocin from the posterior pituitary gland. Complete delivery of the lamb is rapidly accomplished through the combined efforts of uterine contractions augmented by oxytocin and reflexly excited contraction of the maternal abdominal musculature.

Bovine. The corpus luteum is the major source of progesterone throughout gestation (Gomes and Erb, 1965) in the bovine, as compared, to the placenta being the major source of progesterone for the ovine in the last half of gestation. This basic difference in the endocrinology of gestation makes extrapolation of information on parturition between species quite speculative (Liggins, 1972). Jöchle (1971) feels that the maternal adrenal is a more important producer of progesterone for maintenance of pregnancy in the last trimester of gestation in the

bovine than the ovary.

Plasma progesterone levels in the cow are constant throughout most of pregnancy, but about 10 days before parturition they start to decline (Short, 1960). Smith et al. (1973) showed a precipitous decline in serum progestins beginning 72 to 48 hrs prepartum. Others have also measured this drop in progesterone levels in the cow prior to parturition (Short, 1958; Stabenfeldt et al., 1970; Henricks et al., 1972).

Holm and Galligan (1966) showed elevated levels of estradiol and estrone in plasma during the last month of pregnancy and a sharp decline during the postpartum period. Henricks et al. (1972) confirmed the above observation by showing that total estrogens consistently rose in concentration from 14 days prepartum to calving with highest level measured on day of parturition. Smith et al. (1973) showed an increase in plasma levels of estrone and estradiol from start of measurement at 26 days prepartum to a peak at day 2 prepartum. Thereafter, serum estrogens declined rapidly. Estrone showed much higher levels than did estradiol during time of measurement (Smith et al., 1973). Robertson (1974) confirmed these data by showing a rise in the concentration of unconjugated estrone, estradiol-17α and estradiol-17β in the maternal plasma over the last 20 days of pregnancy. At parturition, the concentration of the free estrogens fall to a low level within 24 hrs (Robertson, 1974).

Smith et al. (1973) showed very little change in serum glucocorticoids in the cow from 26 days to 1 day before parturition. However,

an increase approximately 12 hrs before parturition and a peak at parturition was detected in blood glucocorticoids (Smith et al., 1973). Increased glucocorticoids in serum at parturition in the bovine agrees with results reported by Adams and Wagner (1970). Adams and Wagner (1970) showed that glucocorticoids increased markedly to day 4 prepartum then plateaued through parturition not falling until 2 days postpartum. This conflicts with the findings of Smith et al. (1973).

To the knowledge of this author no report of levels of plasma prostaglandin $F_{2\alpha}$ at time of parturition in the bovine have been published. This hormone is thought to be important in the mechanism of parturition in the ovine (Liggins, 1973). Thorburn et al. (1972) has shown increased $PGF_{2\alpha}$ in uterine vein plasma of the goat starting at 24 hrs prepartum and feels that, as in the ovine, $PGF_{2\alpha}$ is important in the mechanism of parturition of the goat. Pharriss, Tillson and Erickson (1972) have shown evidence that $PGF_{2\alpha}$ is luteolytic in various species. Thorburn et al. (1972) theorized that since the goat depends on the CL for progesterone throughout pregnancy (Meites et al., 1951) and progesterone falls prior to parturition because of CL regression that $PGF_{2\alpha}$ could possibly be involved in this regression. However, progesterone levels start decreasing prior to the increase in $PGF_{2\alpha}$ (Thorburn et al., 1972). Nevertheless, Thorburn et al. (1972) feels that since his results were obtained from a single animal in which samples were collected only once daily, the possibility exsists that brief surges of $PGF_{2\alpha}$ were missed. Since the goat and the cow are both

corpus luteum depend, as reported, one might speculate similarities in their mechanisms of parturition.

Ingalls, Convey and Hafs (1973) described changes in serum LH, growth hormone and prolactin concentration in bovine serum during late gestation, parturition and early lactation. Prolactin showed a significant ($P<.01$) increase at -2 and -1.5 days prepartum and reached a peak 1 day before parturition (Ingalls et al., 1973). Ingalls et al. (1973) also demonstrated an increase in maternal serum levels of growth hormone starting on day 9 prepartum through day of parturition with the sharpest increases occurring around parturition. No significant changes were found in plasma LH levels around parturition (Ingalls et al., 1973). Schalms et al. (1972) confirmed the above report on LH levels at parturition. As in the ovine, oxytocin levels show only small changes during labor, but rise to a peak at the actual moment of delivery, and decline rapidly thereafter in the bovine (Chard, 1972).

Plasma cortisol levels were measured in both the bovine fetus and maternal unit by Lin, Oxender and Hafs (1973) at 90, 180 and 260 days of gestation. Their results revealed an increase in fetal cortisol from day 180 to 260 and that maternal cortisol is higher than fetal cortisol throughout gestation. Lin et al. (1973) also reported that cows with a male fetus have a higher maternal cortisol level than cows with a female fetus and male fetuses were found to have higher plasma cortisol levels at 260 days than female fetuses.

At present an accurate theory for the mechanism of parturition in the bovine has not been developed. However, a functional hypothalmic-pituitary-adrenal axis in the fetus is a prerequisite for normal parturition at a predictable term (Holm et al., 1961; Adams, 1969; Liggins, 1972).

Induction of Parturition

General. Liggins (1968), as mentioned earlier, found that infusion of cortisol or ACTH into the ovine fetus leads to premature parturition. He later found that infusion of glucocorticoids into the ovine fetus also leads to premature parturition (Liggins, 1968). However, Liggins (1968) and Liggins (1969) could not induce premature labor in ewes by infusion of cortisol or 4 mg/day of dexamethasone, respectively, into the maternal organism. Nevertheless, much larger dose levels of glucocorticoid given to the ovine mother late in the gestation period causes precocious parturition (Van Rendsburg, 1967; Adams and Wagner, 1970; Skinner et al., 1970; and Fylling, 1971).

In the latter 1960's, veterinary practitioners observed unexplained parturitions in cows treated with corticoid containing drugs during late pregnancy (Carroll, 1974). Adams (1969) confirmed these reports by inducing parturition in 22 cows that were 235 to 280 days pregnant at the time of treatment with flumethasone. At present, successful induction of parturition after maternal injection with glucocorticoids has been reported in rabbits (Kendall and Liggins, 1971; Adams and

Wagner, 1969), goats (Van Rendsburg, 1970), swine (North et al., 1973; First and Staigmiller, 1973; Coggins and First, 1973), and horses (Alm et al., 1972).

There are three major glucocorticoids used at present to induce parturition: dexamethasone, flumethasone and betametasone (Jöchle, 1971). Flumethasone and dexamethasone are the two most commonly used in the United States. The therapeutic efficacy ratio between dexamethasone and flumethasone is 1:4 (Jöchle, 1971). These corticosteroids used in the free alcohol or soluble ester form will induce parturition in cows 2 or 3 days following injection (Welch, Newling and Anderson, 1973). Suspensions or insoluble esters of the above steroids can also be used for inducing parturition, but they usually take about 2 weeks to induce calving after injection (Welch et al., 1973). Some synthetic corticoids do not induce parturition when used at maximum therapeutic doses in late gestation (Lauderdale, 1972).

Zerobin, Jöchle and Steingruber (1973) have shown that prostaglandin $F_{2\alpha}$ or prostaglandin E_2 administered by intravenous or intrauterine application will terminate pregnancy during the last trimester of gestation in the bovine with a live viable calf as a result.

A review of what hormones terminate pregnancy in the bovine during gestation is presented in table 1 (Jöchle, 1973; Zerogin et al., 1973; Lamond et al., 1973).

After parturition is induced prematurely by the infusion of synthetic ACTH or dexamethasone into the fetal lamb, the changes in the

plasma concentration of fetal corticosteroids and maternal progesterone are similar to those seen during normal parturition (Bassett et al., 1969). Thorburn et al. (1972) confirmed the above observation by showing the usual decrease in maternal progesterone before parturition after infusion of synthetic ACTH into the fetal lamb. He also showed

TABLE 1. HORMONALLY INDUCED TERMINATION OF GESTATION IN CATTLE (ADAPTED FROM JÖCHLE, 1973; LAMOND et al., 1973; ZEROBIN et al., 1973)

Compounds used	Trimester		
	I	II	III
(a) Estrogens	+	(+)	(+)
(b) Corticosteroids	-	+	++
(c) Prostaglandins	++	(+)	++
Combination (a) + (b)	+	++	++

Legend: - not active
(+) activity questionable
+ active, but not consistently
++ active, consistently

that the estrogen changes in maternal plasma after induced parturition were similar to those found at normal parturition. Emadi and Noakes (1973) found a definite fall in maternal blood progesterone before parturition when parturition was induced by a maternal injection of glucocorticoid. In the goat plasma conticosteroid concentration increased steadily in the fetus prior to parturition while maternal plasma progesterone levels fell on the day before parturition after induction

of parturition with synthetic ACTH infusions into the fetus (Thorburn et al., 1972). The pattern of maternal estrogen changes was similar in both the normal and ACTH-treated goats (Thorburn et al., 1972). Wright et al. (1970) found that doses of flumethasone given to the female bovine during late gestation caused prompt regression of the corpus luteum as measured by sharp declines in plasma progesterone concentrations, and decreased the estimated size of the CL in those cows responding. Cows not responding did not have reduced progesterone levels. Evans, Wagner and Adams (1971) confirmed the above work by showing a decrease in plasma progesterone within 24 hrs of treatment and a further decrease during the 24 hrs pre-calving. Wagner et al. (1974b) reported that maternal plasma progesterone and estrogen levels of induced cows at time of induced parturition were similar to those of normal cows at parturition. However, the estrogen peak prior to parturition in the induced animals was not of the same magnitude as that of a normal cow. Osinga (1970) showed a short, dramatic rise in urinary estrogen excretion followed by an equally sharp drop in cows induced with corticosteroids.

Response. Adams (1969) induced parturition in 22 cows that were 235 to 280 days pregnant with 20 mg of dexamethasone which is the highest recommended therapeutic dose for the bovine. Adams and Wagner (1970) in a later study used 20 mg of dexamathasone to attempt induction of parturition in cows varying in gestation lengths from 197 to 293 days.

Forty-six of 54 animals were successfully induced with a successful induction defined as one in which labor was initiated within 72 hrs from time of dexamethasone injection. The mean interval to fetal expulsion was 49 hrs after dexamethasone injection with a range of 22-80 hrs (Adams and Wagner, 1970). The mean age of pregnancy for the successes was 274 days with a range of 250-293 days; while the mean age of pregnancy for failures was 254 days with a range of 197-289 days. Adams and Wagner (1970) concluded that since rate of induction failure increased as the dexamethasone was injected earlier in pregnancy, the mechanism apparently becomes more sensitive as the fetus approaches maturity. Bosc (1971) injected either 8 or 16 mg dexamethasone into cows with gestation lengths of 265 or 274 days, and demonstrated that the response varied with the amount injected and the day of pregnancy. The mean hours from injection to parturition was 51.24, 127.93, 34.89 and 58.72 for cows injected with 16 mg on day 265, 8 mg on day 265, 16 mg on day 274 and 8 mg dexamethasone on day 274 of gestation, respectively. Wagner (1972) studied the effect of injecting different levels of dexamethasone on induction of parturition, and showed that in cows in late gestation 30 mg dexamethasone seemed sufficient.

Jöchle (1971) reviewed all available liaterature on the use of flumethasone for induction of parturition. The accumulated data revealed that 5 to 10 mg flumethasone given parenterally 10 to 14 days before calculated termination of pregnancy induced premature parturition

in more than 80% of all treated cows within 48 to 72 hrs. These parturitions are remarkably fast, smooth and uncomplicated. Calf viability is good. These reports also show that larger dose levels are required for successful induction of parturition as you induce earlier in gestation. Jochle (1971) concluded that the closer the gestation period is to term, the more sensitive the maternal organism becomes to this specific corticosteroid effect. Wagner et al. (1971) and Wagner (1972) have confirmed the above data by showing that doses of 5 to 10 mg flumethasone cause parturition in cows when injected in late gestation. Carroll (1974) studied the effects of two dose levels of flumethasone given to cows on day 270 of pregnancy. Hours from treatment to parturition were 56.5 and 52.2 for cows treated with 5 mg flumethasone or 10 mg flumethasone, respectively. There was no significant difference in the response between the dose levels, and there was no correlation between response and weight of cow within each level of treatment (Carroll, 1974). Wiltbank (1973) reported on three trials at Colorado State University in which 10 mg flumethasone was used to induce parturition in the bovine. Average hours from injection to parturition were 50, 44 and 46 hrs, and percent induced were 90, 93 and 96% for Trials I, II and III, respectively.

Bosc (1972b) compared single injections of 4, 8 or 16 mg dexamethasone given to ewes on the 144th day of gestation. Whatever dose of dexamethasone was injected on the 144th day of gestation, the treated animals lambed earlier than the controls. Furthermore, when the dose

was sufficiently high, the variability in the time of lambing was considerably reduced; 75% of sheep treated with 8 or 16 mg of dexamethasone lambed in less than 24 hrs, while the lambing time of those receiving only 4 mg was as long as the controls. Bosc (1972) also revealed a difference in the spread of lambings during a 24 hr period, depending on whether the ewes were injected at 08.00 or 20.00 hrs. As in the bovine, the earlier in gestation the treatment is given, the less effective it becomes (Bosc, 1972). Skinner et al. (1970) showed similar results to those reported above when he gave single injections of flumethasone to ewes between 138 and 140 days of gestation. Sixty percent of the ewes lambed within 50 hrs.

Lucas and Notman (1974) used betamethasone on ewes to induce parturition; all lambings took place between 24 and 69 hrs following injection. No apparent differences in the period of lambing following the different dosages of betamethasone, and the body weight of the ewe were noticed. Parturition can safely be induced in the ovine as early as the 137th day of gestation (Lucas and Notman, 1974), and treatment earlier than this may result in the production of non-viable lambs (Emandi and Noakes, 1973).

Welch et al. (1973) reported on field trials involving 2600 cows treated with long acting corticosteroids (dexamethasone trimethylacetate, triamcinolone acetonide and a suspension of flumethasone). Cows were treated an average of 32 days prior to expected term and calved 19 days prior to expected term. Calf weights of the premature calves were

significantly smaller ($P<.01$) than those of the controls. Calf mortality was extremely high with 28.5% of the calves born dead. Bailey et al. (1973) used a 30 mg dose of dexamethasone trimethylacetate on 30 cows 240-252 days of gestation. All cows responded to treatment with a mean response of 12.1 days; calves born an average of 23.7 days prior to term. Mean gestation lengths for the control and treated cows were 281.5 and 257.8 days, respectively. Bailey et al. (1973) reported that the drug caused no increase in calving difficulty or calf mortality which conflicts with the data reported by Welch et al. (1973). O'Farrell and Crowly (1973) used dexamethasone trimethylacetate on 19 cows 42 to 12 days prior to term. They experienced heavy calf mortality.

Table 2 gives a review of the above mentioned hormones as they relate to induction of parturition in the bovine.

Zerobin et al. (1973) induced premature parturition in 38 of 39 pregnancies with 10 to 50 ml PGE_2 or $PGF_2\alpha$. Parturition took place an average of 3 days after treatment with the interval becoming shorter the closer the treatment was given to calculated term. Development of clinical signs indicative of pending parturition were missing after prostaglandin application, however, the mammary gland developed rapidly after treatment. No complications were encountered with calving difficulty, and all calves born to cows after day 260 in gestation had normal viability. Pregnancies induced with prostaglandin in the above study were accompanied by a high incidence of retained placentas.

TABLE 2. CORTOCOSTEROID-INDUCED PARTURITION IN THE BOVINE COMPOUNDS USED AND DOSE LEVELS OF EFFICACIOUS COMPOUNDS (ADAPTED FROM JÖCHLE, 1973)

Species	Compound used	Effective dose (mg)	Highest ineffective dose (mg)	Therapeutic dose range (mg)	Route of application	Days between maternal treatment and parturition
Cattle						
	Dexamethasone (ester or free alcohol)	10-20	--	10-20	i.m., S.C. intra mammary	1-5
	Dexamethasone (ester)	20	--	10-20	i.m.	10-15
	Triamcinolone	30	--	15-30	i.m.	10-15
	Flumethasone (solution)	5-10	--	2.25-5	i.m.	1-5
	Flumethasone (granulate)	10	7.5	2.5-5	oral	2-5
	Flumethasone (suspension)	10	--	5	i.m.	10-15

Zerobin et al. (1973) recorded uterine contractions during parturition induced with prostaglandin and compared them with contractions at spontaneous parturition and found no differences. They concluded that placental retention observed after induced parturition does not result from an insufficiency in uterine contractility, but points to a disturbance in the mechanisms releasing the placentomes from the cotyledons. In a separate study, $PGF_{2\alpha}$ given on day 270 of gestation caused precocious parturition within 2 to 3 days (R. E. Short, personal communication). However, an extremely high amount of calving difficulty was experienced.

Calf weights are significantly reduced in induced calves as compared to normal calves (Carroll, 1974). Wagner et al. (1974a) showed a significant correlation of birth weight with day of pregnancy at parturition. However, this correlation was not consistent. Crossbred dams showed an increase in their calf birth weight per day of pregnancy of 0.129 kg as compared to that of 0.545 kg for Angus dams. These data indicated that fetuses of crossbred females possibly have an earlier growth pattern in utero than straightbred (Wagner et al., 1974a). The fact that induced calves are lighter at birth than controls has been confirmed by various researchers (LaVoie and Moody, 1973; Beardsley, 1973; Welch et al., 1973; Bailey et al., 1973).

Bellows et al. (1971) reported that birth weight was the most important factor affecting calving difficulty. However, decreased calf weights of induced calves does not decrease calving difficulty

(Carroll, 1974). In fact, in some experiments an increase in calving difficulty has been reported (Bellows, 1972; O'Mary and Coonrad, 1973; Beardsley et al., 1973). Jöchle (1971) in his review of induced parturition studies mentioned no problems with increased calving difficulty in induced cows. Carroll (1974) reported that in certain cases associated with extremely long gestation lengths or high birth weight, there is a significant reduction in the exremely difficult births and those requiring surgical intervention. One other observation concerning parturition is that time from start of labor to expulsion of the fetus is longer in induced cows than in cows experiencing normal parturitions (Wiltbank, 1973). The consequence this has on the factors of parturiton is not known at the present time.

As mentioned earlier Jöchle (1971) reported that calf viability after induction has been good in most cases. This seems to be related to how premature the calf is at birth, with calves born earlier than 270 days having less ability to survive (Carroll, 1974). Everitt and Jury (1972) have shown that calf mortality increases as birth weight decreases. Carroll (1974) concluded that there is some protection against the possiblity of very early calves because cows induced earlier in gestation are less responsive to the influence of corticoids, however, some do respond at a stage of gestation that will not permit survival of the calf. In one study, a high death loss was encountered after parturition was induced at 270 days of gestation (Carroll, 1974).

This decrease in viability could possibly be explained by the fact that control cows had an average gestation length of 290 days, which would have made induced calves 18 to 20 days premature bringing into account the previous reported problem with decreased viability in premature calves (Carroll, 1974). The author concluded that there may be differing optimum times for induction depending on the genotype of the fetus.

Jöchle (1971) reported that the most undesirable side effect of induced parturition was the extremely high percentage of cases of retained placental membranes. The lowest frequency is near term, and increases to 60% or more when birth occurs on day 270 (Carroll, 1974). Wagner et al. (1974a) confirmed this observation with 50% of 294 cows treated with dexamethasone and flumethasone in solution 7-14 days prepartum having retained placentas. Wagner et al. (1974a) obtained a higher frequency in Holstein cows (70.4%) than in Angus (35.9%) which could indicate a possible breed difference.

Morrow et al. (1966) suggested that cows with retained placenta after calving had longer intervals from calving to pregnancy. Since that time, Wagner et al. (1974b) has shown that placental retention does not adversly effect postpartum fertility. No attempt of manual removal of the retained membrane and intramuscular injection of broad spectrum antibiotic after calving were the treatments for cows having retained placenta in the above experiment. Lauderdale (1972) showed

normal postparturient recovery even when no antibiotic treatment was administered.

In order to decrease the incidence of retained placenta in induced cows Karg (1971) injected DES before or simultaneously with flumethasone; this treatment not only lacked the desired results, but also created unexpected complications such as increased dystocia and failure of the proper opening of the cervix at the desired time. LaVoie and Moody (1973a) treated cows with exogenous estrogens twice daily, 6 days prior to corticoid injection, in an attempt to reduce incidence of retained placenta. The number of cows with retained placental membranes was not reduced, but calving difficulty was significantly ($P<.01$) increased. Jöchle et al. (1972) attempted to decrease retention of placental membranes with a progesterone injection applied 3 days before and 5 days after a single administration of 10 mg flumethasone on day 270 of pregnancy. As a result, preparation for presentation of the fetus for parturition was either delayed or prevented, dystocia was frequent, the percentage of stillborn calves was significantly elevated, calf viability was impaired and placental retention was not influenced. Welch et al. (1973) showed only 16% of the cows treated with long acting corticosteroid had retained placentas after calving. Furthermore, Bailey et al. (1973) showed no differences in percent retained placenta between control and treated cows. However, as reported earlier, Welch et al. (1973) showed extremely large amounts

of calf losses. Carroll (1974) acknowledged that occurrence of retained placenta may be predisposing to the development of metritis.

No retained placenta or metritis has been associated with the induction of parturition in the ovine (Adams and Wagner, 1970; Bosc, 1972b).

Subsequent fertility of induced cows has been measured by Carroll (1973) and LaVoie and Moody (1974). Neither study showed a significant difference between induced cows and controls for postpartum fertility. Bailey et al. (1973) showed a significant decrease ($P<.05$) in the days from parturition to first estrus in cows induced with long acting corticosteroid as compared to controls. No significant difference was found when mean time from calving to conception were compared between control and treated groups. One report has shown a decrease in fertility when induced and non-induced cows were compared (Bellows, 1972). Bosc (1972b) reported no difference in postpartum fertility in ewes being treated with dexamethasone as compared to non-treated controls.

Beardsley et al. (1973) induced parturition in Holstein cows with dexamethasone, and showed an average decrease in daily milk production over the first 9 weeks after parturition of 2.9 kg for the induced cows as compared to the controls. No differences in milkfat or fat-corrected milk were found. Fat, protein, total solids, and gama globulin content of colostrum did not differ between groups. Onset of milk production is somewhat slower than normal, however, in limited

observations it is reported that the total production during the following lactation is not influenced (Karg et al., 1971; Osinga et al., 1971). The mean yield of milk and average percent butterfat for cows treated with long acting corticoid were not significantly different from those for the control (Bailey et al., 1973). Colostral immunoglobulin concentration was positively related to the number of days premature in the above study ($r=0.50$, $P<.05$).

Beardsley et al. (1973) found no differences between induced and control calves in total serum protein, albumin, and alpha and beta globulin when measured at birth and 3 days of age. Weekly growth rates were similar for the two groups. LaVoie and Moody (1973b) showed no difference between control and induced calves for weaning weight. Carroll (1974) confirmed this observation by showing no significant difference in weight at weaning. Subsequent weight gains during the suckling period in lambs have not been significantly affected by induced parturition (Bosc, 1972b).

Carroll (1974) reported on the biological activity of corticosteroids in animals. Corticoids have an inhibitory effect on the mechanisms of inflamation, and through this effect could mask the signs of infection and tend to facilitate spread of microorganisms. Sheffy and Davies (1972) reported that administration of corticosteroids caused the reactivation of infectious bovine rhinotracheitis virus in the bovine. If some latent viral infection was present in a number

of the pregnant cows, there could easily be a widespread dissemination of the infective agent to the highly susceptible newborn calves (Carroll, 1974).

Rational for use. Veterinarians have shown a use for corticosteroids in the treatment of various clinical problems, such as prolapse of the vagina and udder edema (Carroll, 1974). Termination of an abnormal pregnancy that constitutes a hazard to the life of mother or fetus is another use. Hydrops allantois is an abnormal condition where glucocorticoids can be used to induce parturition and decrease the hazard to life of the dam (Carter et al., 1971). Glucocorticoids could possibly allow abortion of feedlot or dairy heifers found pregnant after the 5th month of pregnancy (Jöchle, 1971).

The major advantage of using corticosteroid induction of parturition is to control the time of calving (Carroll, 1974). This would provide the opportunity to control the management system so the highest cow and calf survival could be obtained. Carroll (1974) further explained that a reduction in labor is possible because time spent observing cows could be reduced. Constant observation could be given to certain animals where a high incidence of problems is expected, such as twin pregnancies, cows bred to bulls who have a record for difficult calvings, two-year-old heifers and others (Jöchle, 1971). Since calves are born in predetermined groups, one has more uniform calf sizes and ages at weaning (Wagner et al., 1974a). Calf losses could

also be decreased at the beginning and end of the season when less emphasis is usually put on calving (Carroll, 1974). Carroll (1974) also explained the idea of terminating the calving period early. It would also allow to terminate delayed pregnancies after day 290 (Jöchle, 1971).

MATERIALS AND METHODS

This study utilized cattle from the Montana State Prison fall calving beef herd in 1972 and 1973. All animals were managed according to usual open range procedures for western range beef production. Trials 1, 2 and 3 were conducted in the fall of 1972, and trials 11, 12, 13, 14, 15 and 16 were conducted in the fall of 1973.

Fall calving, 1972. Animals used in the first and second trials were Hereford and Hereford x Red Angus first calf heifers. In the third trial, Hereford and Hereford x Red Angus aged cows were used. Projected calving dates were available for the heifers used in the first trial, but were not available for all heifers and cows in trials 2 and 3 because of incomplete breeding information. All cows and heifers had been bred A.I. for 25 days, then by natural service for another 20 days.

The cows and heifers in trials 2 and 3 were animals that did not conceive or were not bred during the A.I. breeding period, but did conceive in the subsequent natural breeding period. The bulls used in natural service were of a different breed than those used in artificial insemination.

Breeding dates for pregnant heifers and cows which were bred but didn't conceive during the A.I. period were calculated by adding 20 or 21 days, respectively, to the A.I. breeding dates. If a prior A.I. date was not available, no estimate was made. All heifers were considered to have 281-day gestation lengths (Clegg, 1959) and cows

a 285-day gestation length (Kenneth, 1953).

In trial 1, 48 heifers were randomly assigned to three treatment groups; treatment 1, control; treatment 2, 20 mg of dexamethasone given intravenously (I.V.) and treatment 3, 20 mg of dexamethasone given intramuscularly (I.M.). The heifers in the two dexamethasone groups were treated 7 to 14 days prior to their expected normal calving date.

In trial 2, 48 heifers were assigned to 3 treatment groups; treatment 1, non-treated; treatment 2, 20 mg of dexamethasone I.M. followed in 24 hrs by 20 mg of dexamethasone I.V. and treatment 3, 10 mg of dexamethasone I.M. followed in 24 hrs by 20 mg of dexamethasone I.M. This trial consisted of the last heifers due to calve in the calving period; therefore, all heifers were treated 14 days prior to the end of the expected calving period. Heifers in treatment 1 were those which calved in the 4-day period prior to the time of injection of induced animals. All other heifers were randomly assigned to treatments 2 and 3.

In trial 3, 76 cows were assigned to 3 treatment groups; treatment 1, non-treated; treatment 2, 20 mg of dexamethasone I.M. followed in 24 hrs by 30 mg of dexamethasone I.M., and treatment 3, 20 mg of dexamethasone I.V. followed in 24 hrs by 20 mg of dexamethasone I.M. The cows in this trial were the last due to calve in the calving period; therefore, all cows were injected 11 days prior to the expected termination date of calving. Cows in treatment 1 were those cows that calved in the 14-day period prior to the time of parturition induction in

treatments 2 and 3. All cows in treatments 2 and 3 were randomly assigned.

Cows were observed at approximately 4-hr intervals daily around time of expected parturition. Date, time and complications of parturition along with weight and viability of the offspring were recorded at time of parturition. Calving difficulty was scored using the following method: 1=unassisted, normal presentation, 2=assistance with hand traction, normal presentation, 3=assistance with mechanical puller, normal presentation, 4=extremely difficult pull and/or malpresentation (LaVoie and Moody, 1973a). Calf vigor was scored from 1 to 4 depending on the viability of the calf at birth: 1=very vigorous, 2=normal, 3=weak, 4=very weak or dead (LaVoie and Moody, 1973a). Parturition was considered induced if the cow calved within 96 hrs of the first injection of dexamethasone. Incidence of visible retained placenta was recorded at 24 hrs, 48 hrs and 72 hrs after parturition. After the 72-hr observation, the cows were released into a fenced pasture and watched daily for placental retention and any other complications. Cows with retained placental membranes at the time of each observation were injected with 20 cc of a broad spectrum antibiotic (penicillin and dihydrostreptomycin).

All heifers that did not respond to the induction treatments in the first two trials (6 heifers) were allowed to calve normally, or were injected with dexamethasone at a later date. Data from these cows were not statistically analyzed and is reported in table 3.

TABLE 3. DATA FROM COWS WHICH WERE TREATED IN THE FIRST AND SECOND TRIALS, BUT DID NOT INDUCE

Cow No.	Gestation length (days)	Birth wt. (kg)	Retained placenta 24 hrs	Retained placenta 48 hrs	Retained placenta 72 hrs	Vigor (1-4)	Difficulty (1-4)	Prior treatment
0104	277	28.18	+	+	+	2	1	2 (1)
0118	277	20.45	-	-	-	2	1	2 (1)
0200**	278	28.18	+	+	+	2	1	3 (1)
0100**	290	37.27	-	-	-	1	1	3 (2)
0120**	279	30.90	-	-	-	2	1	2 (2)

**Cows which were retreated with dexamethasone and were successfully induced.
+ Placental retention
- No placental retention
Numbers in parentheses are trials where first treated.

All cows in trials 1, 2 and 3 were then subjected to a 45-day breeding season consisting of a 25 day A.I. period followed by a 20 day natural service period. The average days from calving to the start of the breeding season were: 78, 78 and 78 days for trial 1, treatments 1, 2 and 3, respectively, 60, 57 and 57 days for trial 2, treatments 1, 2 and 3, respectively, and 56, 44 and 44 days for trial 3 treatments 1, 2 and 3, respectively. Pregnancy diagnosis by means of rectal palpation was then made at 37 days after the A.I. period ended and again at 123 days after the end of the breeding season. Fertility was then measured both by the percent pregnant at 123 days after the breeding season and by a fertility score for the first 25 days of breeding. The fertility score was determined using the following method: 0 = no breeding date during first 25 days of the breeding season, 1 = breeding date during first 25 days of breeding season but determined non-pregnant by first palpation, 2 = breeding date during first 25 days of breeding season and determined pregnant by first palpation. Non-responding animals were excluded from the analysis.

All calves in trials 1, 2 and 3 were weighed and subsequently weaned at an average of 236, 236 and 236 days after calving for trial 1, treatments 1, 2 and 3, respectively, 218, 215 and 215 days after calving for trial 2, treatments 1, 2 and 3, respectively, and 214, 202 and 202 days after calving for trial 3, treatments 1, 2 and 3, respectively. Performance of the calves was then measured by

actual weaning weight, 205-day adjusted weight and average daily gain from birth to weaning. Kilograms of calf weaned per cow responding to induction treatment (controls included) was used as a more complete measure of subsequent performance. Non-induced animals were excluded from the analysis.

Fall calving 1973. Animals used in trials 11 through 14 were out of the same general population as the cows in trials 1 through 3. These cows were Hereford, Hereford x Red Angus and Hereford x Charolais. In trials 15 and 16 primarily Hereford first calf heifers were used. Projected calving dates were available for cows in trials 11 and 12 and heifers in trials 15 and 16, but were not available for all cows in trials 13 and 14 because of incomplete breeding information. All cows and heifers had been bred A.I. for 25 days, then by natural service for another 20 days. Each cow was bred artificially to one of four sires (2 Simmental and 2 Hereford) while the heifers were bred artificially to a Devon sire. Various Hereford and Hereford x Simmental sires were used for natural service.

The cows in trial 13 were a combination of animals with predicted calving dates and those that did not conceive during the A.I. breeding period, but did conceive in the subsequent natural breeding period. Cows in trial 14 were animals that did not conceive or were not bred during the A.I. period, but did conceive in the subsequent natural breeding period.

Breeding dates for pregnant cows which were bred but didn't conceive during the A.I. period were calculated by adding 21 days to the A.I. breeding dates. If a prior A.I. date was not available, no estimate was made. Heifers were considered to have 281 day gestation lengths (Clegg, 1959) and cows 285 day gestation lengths (Kenneth, 1953).

The cows due to calve within the 45-day breeding season were randomly assigned to trials and treatments prior to the commencement of the experiment. The natural calving season was due to start on day 236 and end on day 291 of the year, and an induction schedule was developed to divide the natural calving period into 4 separate induction trials approximately 10 days apart (Figure 2). An extra induction was added 4 days after the final scheduled induction to take care of cows which did not calve as a result of the 4th induction treatment. All cows were randomly assigned to control or treatment group as to length of gestation, prior years treatment (0, not assigned to treatment in fall of 1972, 1, not treated in fall 1972 induction experiment and 3, treated with dexamethasone to cause early parturition in fall 1972) and sire of calf.

In trial 11, 70 cows were randomly assigned to three treatment groups; treatment 1, control; treatment 2, 10 mg of flumethasone (I.M.) and treatment 3, 5 mg of flumethasone (I.M.) followed in 12 hrs by another 5 mg of flumethasone (I.M.). The cows in the two flumethasone groups were treated 6 to 13 days prior to the expected normal calving

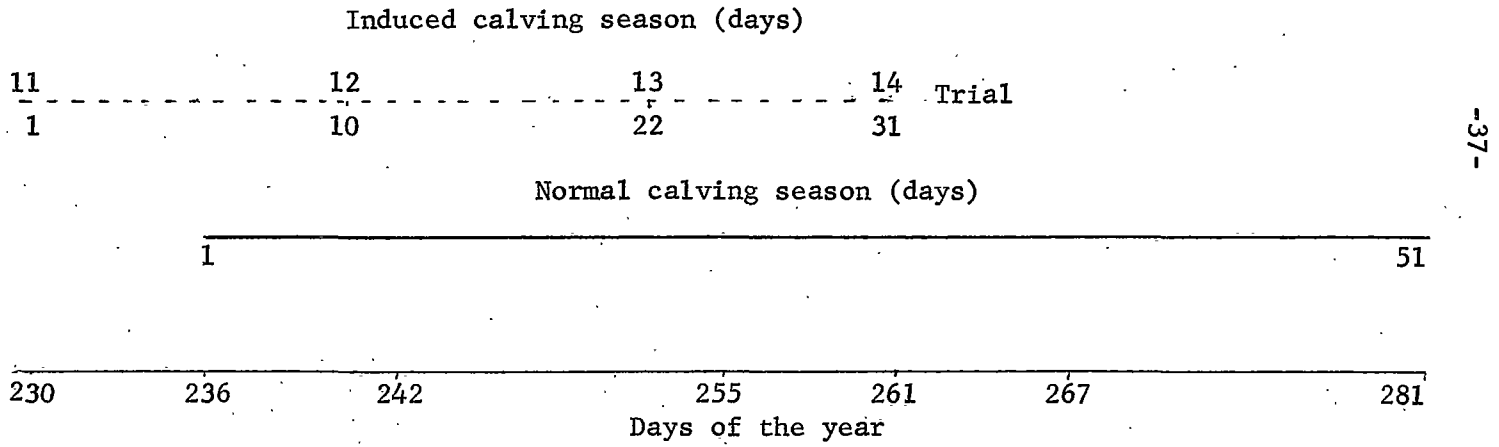


Figure 2. Schedule of induced calving season as compared to projected length of normal calving season in trials 11-14.

date. Cows not responding to flumethasone treatment were retreated on day 240 of the year with 10 mg of flumethasone. All cows that had retained placental membranes at 24 hrs after parturition were injected at 36 to 49 hrs post calving with 20 cc of broad spectrum antibiotics (200,000 units procaine penicillin G and 250 mg dihydrostreptomycin mixed).

In trial 12, 75 cows were randomly assigned to the three treatment groups; treatment 1, control; treatment 2, 10 mg of flumethasone (I.M.) and treatment 3, 5 mg of flumethasone (I.M.) followed in 12 hrs by another 5 mg of flumethasone (I.M.). The cows in the two flumethasone groups were treated 4 to 14 days prior to the expected normal calving date with one cow accidentally being treated 26 days prior to her expected normal calving date. Cows not responding to flumethasone treatment were allowed to calve normally without retreatment. Ten cows in treatment 2 were injected at time of flumethasone treatment with 20 cc of long acting broad spectrum antibiotics (150,000 units benzathine penicillin G, 150,000 units procaine penicillin G and 250 mg dihydrospectomycin mixed) for protection against systemic infection in case of placental retention. All other cows were injected between 24 and 36 hrs after parturition with 20 cc of broad spectrum antibiotic (procaine penicillin G and dihydrostreptomycin mixed) if they had a retained placenta at 24 hrs after parturition.

In trial 13, 34 cows were randomly assigned to three treatment

groups; treatment 1, control; treatment 2, 10 mg of flumethasone (I.M.) and treatment 3, 7.5 mg of flumethasone (I.M.). The cows in the two flumethasone groups were treated 3 to 14 days prior to the expected normal calving date. One of the cows not responding to treatment was allowed to calve normally and the other was retreated with 10 mg of flumethasone on day 261 of the year. All cows that had retained placental membranes at 12 hrs after parturition were injected with 20 cc of broad spectrum antibiotics (procaine penicillin G and dihydrostreptomycin mixed) within 12 to 36 hrs after parturition.

In trial 14, 96 cows were randomly assigned to 3 treatment groups: treatment 1, controls; treatment 2, 10 mg of flumethasone (I.M.) given at 700 hrs and treatment 3, 10 mg of flumethasone (I.M.) given at 1900 hrs on the same day. This trial consisted of the last cows due to calve in the calving period; therefore, all cows were treated 20 days prior to the end of the expected calving period. Cows not responding to flumethasone treatment were retreated on day 265 of the year with 15 mg of flumethasone. Twenty-six and 29 cows in treatments 2 and 3, respectively, were injected with 20 cc of long acting broad spectrum antibiotic (benzathine penicillin G, procaine penicillin G and dihydrostreptomycin mixed) at time of flumethasone treatment and turned out into an 8 acre pasture to await parturition. The rest of the cows 11 and 9 in treatments 2 and 3, respectively, were calved in a corral. These cows were also injected with 20 cc of long acting broad spectrum

antibiotic at time of flumethasone treatment. Placental retention was recorded between 12 and 24 hrs on all cows in trial 14.

In trial 15, 18 two-year-old heifers were randomly assigned to two treatment groups; treatment 1, control and treatment 2, 10 mg of flumethasone (I.M.). The heifers in the flumethasone treated group were injected 2 to 12 days prior to the expected normal calving date. All heifers diagnosed as having retained placental membranes at 24 hrs after parturition were injected at 36 to 48 hrs postcalving with 20 cc of broad spectrum antibiotics (procaine penicillin and dihydrostreptomycin mixed).

In trial 16, 12 two-year-old heifers were randomly assigned to two treatment groups; treatment 1, control and treatment 2, 10 mg of flumethasone (I.M.). The heifers in the flumethasone treated group were injected 4 to 12 days prior to the expected normal calving date. Heifers were injected between 24 and 36 hrs after parturition with 20 cc of broad spectrum antibiotic if diagnosed as having a retained placenta at 24 hrs after parturition.

Cows and heifers in the flumethasone treated groups in trials 11, 12, 13, 15 and 16 were observed at approximately two hour intervals daily around time of expected parturition. The cows in trial 14 that were flumethasone treated and turned out in an 8 acre pasture were observed at approximately 4 hr intervals in the day but were not observed for approximately 6 hrs each night between 2300 and 500 hrs. The remaining

flumethasone treated cows in trial 14 were observed at approximately 2 hr intervals around expected parturition. All controls in the 6 trials were observed at approximately 8 hr intervals at all times. Date, time and complications of parturition along with weight and viability of the offspring were recorded at time of parturition. Calving difficulty was scored using the following method: 1=unassisted, normal presentation, 2=assistance with hand traction, normal presentation, 3=assistance with mechanical puller, normal presentation, 4=extremely difficult pull, normal presentation and .5 added to any of the above score for a malpresentation. Calf vigor was scored from 1 to 3 depending on the viability of the calf at birth: 1=normal, 2=weak, 3=very weak or dead. Parturition was considered induced if the cow calved within 96 hrs of the first injection of flumethasone. Incidence of retained placenta was recorded between 12 and 24 hrs after parturition and again at approximately one week after parturition.

All cows in trials 11, 12, 13, 14, 15 and 16 were then subjected to a 45 day breeding season consisting of a 25 day A.I. period followed by a 20 day natural service period. The average days from calving to the start of the breeding season were: 80, 85 and 87 days for trial 11, treatments 1, 2 and 3, respectively, 69, 76 and 76 days for trial 12, treatments 1, 2 and 3, respectively, 65, 64 and 64 days for trial 13, treatments 1, 2 and 3, respectively, 47, 56 and 55 days for trial 14, treatments 1, 2 and 3, respectively, 80 and 85 days for trial 15,

treatments 1 and 2, respectively, and 65 and 76 days for trial 16, treatments 1 and 2, respectively. Pregnancy diagnosis by means of rectal palpation was then made at 44 days after the end of the breeding season. Fertility was then measured both by the percent pregnant at 44 days after the breeding season and by a fertility score for the first 25 days of breeding. The fertility score was determined using the following method: 0=no breeding date during the first 25 days of the breeding season, 1=breeding date during first 25 days of breeding season but determined non-pregnant to this first breeding, 2=breeding date during first 25 days of breeding season and determined pregnant to this first breeding.

The data were analyzed for all traits, except kg of calf weaned per cow successfully treated, by the least squares method as discussed by Harvey (1960). The following general model was used to analyze the data.

$$y_{ijklm} = u + t_i + b_j + s_k + p_l + e_{ijklm}$$

where

y_{ijklm} = observation on the m^{th} individual in the i^{th} treatment by the j^{th} sire of the k^{th} sex in the l^{th} previous treatment.

u = fixed underlying population mean

t_i = effect of i^{th} treatment

b_j = effect of j^{th} sire of the calf

s_k = effect of k^{th} sex of the calf

p_l= effect of l^{th} previous treatment

e_{ijklm}= random errors

In the analysis of data from the fall 1972 calving, effects of sire, sex and previous treatment were deleted from the above model. Sire effect was deleted because of a lack of this information on the animals. Previous treatment was deleted because of no previous induction experiments on this particular herd. Sex of calf was deleted because it deomonstrated no effect on treatment response. In analyzing subsequent fertility and calf performance in these cows, the effects of sire and previous treatment were deleted from the model and a sex x treatment interaction was added. The partial regressions of observation on gestation length at injection, hours from injection to parturition and birth weight were added to the model for the analysis of a combination of trials 11 and 12 and a combination of trials 11, 12, 13 and 14. Non-responding animals were excluded from the above trial combination analyses except for the analysis of induction success. Non-significant regressions were deleted from the statistical model. Standard partial regression coefficients were calculated to measure relative importance of x variables if more than one x variable was found to significantly affect a y variable ($P<.05$). Also a treatment x trial interaction was added to the model when any analysis was run across trials. To analyze the subsequent breeding performance of the fall 1973 data sex and sire effects were deleted from the model.

Placental retention (0=not retained and 1=retained) at 24 hr and 1 week post parturition along with the partial regression of observation on gestation length at time of parturition were added to the model when trials 11, 12, 13, and 14 were combined for analysis (non-induced animals deleted). Student-Newman-Keuls test (Snedecor and Cochran, 1967) was applied whenever the least squares analysis indicated significant difference. Kilograms of calf weaned per cow successfully treated for each treatment was calculated by multiplying the least squares mean for actual weaning weight by the number of calves actually weaned and then dividing by the number of cows that responded to the induction treatment: or in the case of controls the number of animals calved as controls. The averages from each of the control treatments in trials 1 through 3 and averages of the two induction treatments in trials 1 through 3 were then statistically analyzed by a t test (Snedecor and Cochran, 1967).

The traits analyzed in trials 1, 2 and 3 were birth weight, calf vigor, calving difficulty, gestation length (where available), retained placenta, hours from injection to calving, induction success, percent pregnant after 45 day breeding season, fertility score for first 25 days of breeding, actual weaning weight of calves, adjusted 205-day weaning weight of calves (adjusted only for age of calf) and average daily gain from birth to weaning of calves. An analysis of birth date was added when the data from trials 11, 12, 13, 14, 15 and 16 were

analyzed, and all measures of subsequent calf performance were excluded because they were not yet available.

Least-squares analysis of variance tables for each statistical analysis are in the appendix.

RESULTS

Fall calving 1972

In trial 1 (Table 4) parturition was induced an average of 57.4 and 52.5 hrs after dexamethasone injection in 83.3 and 81.8% of the cows in treatments 2 and 3, respectively. Consequently, gestation length was shortened ($P<.01$) in comparison to the controls (Treatment 1) by 7.4 days in treatment 2 and 6.5 days in treatment 3. Birth weight and calf vigor were not significantly affected by treatment, but calving difficulty was higher ($P<.05$) in treatment 2 than in treatments 1 or 3. There was a significant increase ($P<.01$) in the incidence of retained placenta in the treated groups over the control at 24 and 72 hrs after calving. A comparison between treatment 2 and 3 revealed no significant differences in induction rate, hours from injection to parturition or incidence of retained placenta.

In trial 2 (Table 5) parturition was induced an average of 49.2 and 48.6 hrs after the first dexamethasone injection in 95.2 and 94.4% of the cows in treatments 2 and 3, respectively. A statistical analysis of gestation length was not done in trial 2 because of a lack of accurate breeding data. There were no significant differences between treatment groups in birth weight, calving difficulty, calf vigor, and incidence of retained placenta at 24 and 72 hrs.

All of the dexamethasone treated cows in trial 3 (Table 6) responded within 96 hrs after injection. Lack of accurate data on breeding date and time of parturition prohibited a statistical analysis of

TABLE 4. EFFECT OF DEXAMETHASONE (DEX) GIVEN IN A SINGLE DOSE INTRAMUSCULARLY (I.M.) VS. INTRAVENOUSLY (I.V.) ON HEIFERS AND CALVES THAT RESPONDED TO TREATMENT[a] (TRIAL 1)

Measurement	Treatment 1 Control	Treatment 2 20 mg (DEX) I.V.	Treatment 3 20 mg (DEX) I.M.
No. cows	16	10 [12]	9 [11]
Birth wt. (kg)	29.5(0.882)	26.8(1.117)	27.6(1.177)
Calf vigor (1-4)	1.88(0.106)	2.0(0.134)	2.0(0.141)
Calving difficulty (1-4)	1.00(0.143)[e]	1.60(0.180)[d]	1.00(0.190)[e]
Gestation length (days)	280.5(0.814)[b]	273.1(1.029)[c]	274(1.085)[c]
Retained placenta (24 hrs)	0.063(0.098)[c]	0.600(0.124)[b]	0.778(0.130)[b]
Retained placenta (72 hrs)	0.000(0.088)[c]	0.600(0.111)[b]	0.778(0.117)[b]
Period of gestation at time of injection (days from term)	--	-14 to -7	-12 to -7
Hours from injection to parturition	--	57.4(2.89)	52.5(3.046)
Induction success, %	--	83.3	81.8

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

[bc] Averages in the same line not having the same superscript differ significantly ($P<.01$)

[de] Averages on the same line not having the same superscript differ significantly ($P<.05$)

TABLE 5. EFFECT OF DEXAMETHASONE (DEX) GIVEN IN TWO INJECTIONS OF DIFFERENT TOTAL DOSAGE AT A 24 HOUR INTERVAL ON HEIFERS AND CALVES THAT RESPONDED TO TREATMENT[a] (TRIAL 2)

Measurement	Treatment 1 Control	Treatment 2 20 mg I.M.	Treatment 2 20 mg I.V.	Treatment 3 10 mg I.M.	Treatment 3 20 mg I.M.
No. cows	8	20 [21]		17 [18]	
Birth wt. (kg)	31.4(1.491)	30.5(0.937)		32.9(1.016)	
Calf vigor (1-4)	2.0(0.089)	1.80(0.056)		1.88(0.061)	
Calving difficulty (1-4)	1.0(0.227)	1.3(0.143)		1.2(0.156)	
Retained placenta (24 hrs)	0.000(0.155)	0.350(0.098)		0.294(0.106)	
Retained placenta (72 hrs)	0.000(0.145)	0.350(0.091)		0.177(0.099)	
Period of gestation at time of injection (days from term)	--	-14 to +3		-11 to -1	
Hours from injection to parturition	--	51.0(2.729)		48.7(2.960)	
Induction succes, %	--	95.2		94.4	

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

TABLE 6. EFFECT OF DEXAMETHASONE (DEX) GIVEN IN TWO INJECTIONS OF DIFFERENT TOTAL DOSAGE AT A 24 HOUR INTERVAL ON COWS AND CALVES THAT RESPONDED TO TREATMENT[a] (TRIAL 3)

Measurement	Treatment 1 Control	Treatment 2 20 mg I.M.	Treatment 2 30 mg I.M.	Treatment 3 20 mg I.V.	Treatment 3 20 mg I.M.
No. cows	31	24 [24]		21 [21]	
Birth wt. (kg)	31.0(0.791)	31.8(0.409)		33.0(0.961)	
Calf vigor (1-4)	2.13(0.058)	2.00(0.065)		2.00(0.070)	
Calving difficulty (1-4)	1.0(0.041)	1.1(0.047)		1.0(0.050)	
Retained placenta (24 hrs)	0.000(0.065)**[e]	0.375(0.073)**[ed]		0.238(0.079)[d]	
Retained placenta (72 hrs)	0.000(0.059)[e]	0.250(0.067)[d]		0.191(0.071)[d]	
Period of gestation at time of injection (days from term)	--	-11 to 0		-11 to +2	
Induction success, %	--	100		100	

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

[de] Averages on the same line not having the same superscript differ significantly ($P<.05$).

**These averages differ significantly ($P<.01$).

gestation length and the interval from injection to parturition. There were no significant differences between treatment groups in birth weight, calving difficulty or calf vigor, but there were significant differences ($P<.05$ and $P<.01$) in the incidence of retained placenta between the dexamethasone treated groups and controls at 24 and 72 hrs post-calving.

There were no significant differences in reproductive performance between the three treatment groups as measured by pregnancy rate after a 45 day breeding season and average fertility score for the first 25 days of breeding in trial 1 (Table 7). Pregnancy rates were 81.3, 70 and 100% and fertility scores were 1.06, 1.38 and 1.8 for treatments 1, 2 and 3, respectively.

In trial 2 (Table 8) pregnancy rates were 62.5, 75 and 58.8% and fertility scores were 0.86, 1.34 and 0.74 for treatments 1, 2 and 3, respectively, but there were no significant differences between the groups.

In trial 3 (Table 9) pregnancy rates were 83.9, 78.2 and 80.9% and fertility scores were 1.3, 1.08 and 1.41 for treatments 1, 2 and 3, respectively. None of the above differences proved to be statistically significant.

No significant differences were found in subsequent calf performance to weaning when treatments 1, 2 and 3 were compared in trial 1 (Table 10). Actual weaning weights were 135.4, 133 and 139.1 kg

TABLE 7. SUBSEQUENT FERTILITY OF INDUCED HEIFERS RECEIVING A SINGLE DOSE OF DEXAMETHASONE (DEX) GIVEN INTRAMUSCULARLY (I.M.) VS. INTRAVENOUSLY (I.V.)[a] (TRIAL 1)

Measurement	Treatment 1 Control	Treatment 2 20 mg (DEX) I.V.	Treatment 3 20 mg (DEX) I.M.
No. cows	16	10 [12]	9 [11]
Pregnant after 45 day breeding season	0.859(0.118)	0.767(0.158)	1.09(0.179)
Fertility score first 25 days of breeding	1.06(0.248)	1.38(0.331)	1.80(0.376)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

TABLE 8. SUBSEQUENT FERTILITY OF INDUCED HEIFERS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL[a] (TRIAL 2)

Measurement	Treatment 1 Control	Treatment 2 20 mg I.M.	Treatment 2 20 mg I.V.	Treatment 3 10 mg I.M.	Treatment 3 20 mg I.M.
No. cows	8	20 [21]		17 [18]	
Pregnant after 45 day breeding season	0.722(0.202)	0.774(0.110)		0.667(0.133)	
Fertility score first 25 days of breeding	0.861(0.337)	1.34(0.183)		0.744(0.221)	

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least quares means.

TABLE 9. SUBSEQUENT FERTILITY OF LATE CALVING AGED COWS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL[a] (TRIAL 3)

Measurement	Treatment 1 Control	Treatment 2 20 mg I.M.	Treatment 2 30 mg I.M.	Treatment 3 20 mg I.V.	Treatment 3 20 mg I.M.
No. cows	30	24 [24]		21 [21]	
Pregnant after 45 day breeding season	0.836(0.078)	0.806(0.086)		0.865(0.149)	
Fertility score first 25 days of breeding	1.30(0.179)	1.08(0.198)		1.41(0.343)	

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

TABLE 10. SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS RECEIVING A SINGLE DOSE OF DEXAMETHASONE (DEX) GIVEN INTRAMUSCULARLY (I.M.) VS. INTRAVENOUSLY (I.V.)[a] (TRIAL 1).

Measurement	Treatment 1 Control	Treatment 2 20 mg (DEX) I.V.	Treatment 3 20 mg (DEX) I.M.
No. calves	14 [16]	9 [10]	9 [9]
Actual weaning wt. (kg)	135.4(6.011)	133.0(7.230)	139.1(8.641)
Adj. 205-day wt. (kg)	124.7(5.234)	121.1(6.527)	127.9(6.527)
ADG (birth to weaning) (kg)	0.464(0.024)	0.459(0.030)	0.491(0.030)
Kg of calf weaned/cow[b]	118.5	119.7	139.1

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows successfully treated. All averages are least squares means (kg).

[b] These averages were not statistically analyzed by trial.

and kg of calf weaned per cow successfully induced were 118.5, 119.7 and 139.1 kg for treatments 1, 2 and 3, respectively.

Actual weaning weights were 122.4, 131.6 and 136.1 kg and kg of calf weaned per cow successfully induced were 107.1, 98.7 and 112.1 kg in treatments 1, 2 and 3, respectively, trial 2 (Table 11). However, there were no significant differences found between groups when the above averages for actual weaning weight were compared. No significant differences in the other measured parameters were found between treatment groups when compared.

In trial 3 (Table 12) no significant differences were found between groups when subsequent calf performance was compared. Actual weaning weights were 137.5, 125.5 and 128.3 kg for treatments 1, 2 and 3, respectively.

A statistical analysis comparing controls with induced animals across trials 1, 2 and 3 for kg of calf weaned per cow successfully induced revealed no significant differences between the groups.

Fall calving 1973

In trial 11 (Table 13) parturition was induced after flumethasone injection in 92.3 and 95.2% of the cows in treatments 2 and 3, respectively. Two cows, one from each induction treatment did not respond to flumethasone treatment, but were retreated with flumethasone 10 days later. Both calved as a result of retreatment. Consequently, the average birth date of the two non-induced cows was 241.1 as compared to

TABLE 11. SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL[a] (TRIAL 2)

Measurement	Treatment 1 Control	Treatment 2 20 mg I.M.	Treatment 2 20 mg I.V.	Treatment 3 10 mg I.M.	Treatment 3 20 mg I.M.
No. calves	7 [8]	15 [20]		14 [17]	
Actual weaning wt. (kg)	122.4(7.140)	131.6(4.838)		136.1(5.530)	
Adj. 205-day wt. (kg)	117.9(7.252)	126.6(4.954)		130.2(5.128)	
ADG (birth to weaning) (kg)	0.418(0.034)	0.468(0.023)		0.477(0.024)	
Kg of calf weaned/cow[b]	107.1	98.7		112.1	

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows successfully treated. All averages are least squares means (kg).

[b] These averages were not statistically analyzed by trail.

TABLE 12. SUBSEQUENT PERFORMANCE OF CALVES FROM LATE CALVING AGED COWS RECEIVING TWO DOSES OF DEXAMETHASONE (DEX) AT A 24 HOUR INTERVAL[a] (TRIAL 3)

Measurement	Treatment 1 Control	Treatment 2 20 mg I.M.	Treatment 2 30 mg I.M.	Treatment 3 20 mg I.V.	Treatment 3 20 mg I.M.
No. calves	25 [31]	18 [24]		20 [21]	
Actual weaning wt. (kg)	137.5(4.225)	125.5(5.102)		128.3(4.743)	
Adj. 205-day wt. (kg)	133.6(4.203)	128.0(5.097)		129.8(4.699)	
ADG (birth to weaning) (kg)	0.505(0.019)	0.468(0.023)		0.473(0.021)	
Kg of calf weaned/cow[b]	110.9	94.1		122.2	

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows successfully treated. All averages are least squares means (kg).

[b] These averages were not statistically analyzed by trial.

TABLE 13. EFFECT OF FLUMETHASONE (FLU) GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES AT PARTURITION[a] (TRIAL 11)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 10 mg (Flu) double injection	Cows not responding to treatment
No. cows	36	12 [13]	20 [21]	2
Birth date (day of year)	238.3(0.709)^{dbc}	232.6(0.972)^{ce}	231.2(0.776)^{ce}	241.1(2.333)^{b}
Birth wt. (kg)	34.2(0.998)	32.2(1.383)	30.6(1.089)	28.2(3.311)
Calf vigor (1-3)	1.06(0.063)	0.97(0.087)	1.03(0.069)	1.00(0.208)
Calving difficulty (1-4)	0.96(0.056)	1.07(0.077)	1.10(0.061)	0.90(0.184)
Gestation length (days)	284.3(0.702)^{bd}	278.8(0.962)^{ebc}	277.5(0.768)^{ce}	283.9(2.308)^{bd}
Retained placenta (24 hrs)	0.088(0.084)	0.605(0.115)	0.692(0.092)	0.534(0.275)
Retained placenta (1 week)	0.039(0.083)	0.358(0.113)	0.373(0.090)	0.431(0.271)
Period of gestation at time of injection (days from term)	--	-13 to -6	-13 to -6	-13 to -12

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

bc Averages on the same line not having the same superscript differ significantly ($P<.01$).

de Averages on the same line not having the same superscript differ significantly ($P<.05$).

232.6 and 231.2 for treatments 2 and 3 ($P<.01$), respectively. Gestation length for responding animals was shorter by 5.1 days ($P<.05$) in treatment 2 and by 6.4 days ($P<.01$) in treatment 3 than in the non-responding animals. No other significant differences were found when non-responding animals were compared to responding animals in treatments 1, 2 and 3 for all measured parameters.

Non-induced animals were then excluded from the analysis (Table 14). Average birth dates were 238.3, 232.6 and 231.2 for treatments 1, 2 and 3, respectively, with animals in treatment 1 (control) having an average birth date significantly ($P<.01$) later in the year than those animals in treatments 2 or 3. Birth weight for the control group was greater than that of treatment 3 ($P<.05$) but no difference was found when the control and treatment 3 were compared with treatment 2. Gestation length was shortened ($P<.01$) in comparison to controls by 5.5 and 6.8 days in treatments 2 and 3, respectively. There was a significant increase ($P<.01$) in the incidence of retained placenta in the treated groups over the control at 24 hrs. At 1 week, the animals in treatment 2 ($P<.05$) and treatment 3 ($P<.01$) showed significantly higher incidence of retained placental membranes than the control. No other significant differences between groups were found in measured parameters.

In trial 12 (Table 15) parturition was induced in 86.4 and 100% of the cows in treatments 2 and 3, respectively. Three cows in treatment 2 failed to respond to flumethasone treatment within 96 hrs of

TABLE 14. EFFECT OF FLUMETHASONE (FLU) GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION[a] (TRIAL 11)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 10 mg (Flu) double injection
No. cows	36	12 [13]	20 [21]
Birth date (day of year)	238.3(0.717)[b]	232.6(0.981)[c]	231.2(0.783)[c]
Birth wt. (kg)	34.4(0.998)*	32.4(1.361)	30.8(1.089)*
Calf vigor (1-3)	1.06(0.064)	0.97(0.087)	1.03(0.070)
Calving difficulty (1-4)	0.96(0.057)	1.07(0.077)	1.10(0.062)
Gestation length (days)	284.3(0.710)[b]	278.8(0.971)[c]	277.5(0.775)[c]
Retained placenta (24 hrs)	0.029(0.083)[b]	0.598(0.113)[c]	0.686(0.090)[c]
Retained placenta (1 week)	0.030(0.081)[b*]	0.350(0.111)[*bc]	0.367(0.089)[c]
Period of gestation at time of injection (day from term)	--	-13 to -6	-13 to -6
Hours from injection to parturition	--	49.68(4.112)	46.48(3.446)
Induction success[d]	--	1.133(0.112)	1.171(0.098)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

[bc] Averages on the same line not having the same superscript differ significantly ($P<.01$).

* These averages differ significantly ($P<.05$)

[d] One more cow was added to treatment 3 for this analysis.

TABLE 15. EFFECT OF FLUMETHASONE GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE (FLU) GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES AT PARTURITION[a] (TRIAL 12)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 10 mg (Flu) double injection	Cows not responding to treatment
No. cows	34	19 [22]	19 [19]	3
Birth date (day of year)	248.6(0.952)[d]	241.9(1.102)[c]	242.4(1.191)[c]	254.9(2.695)[b]
Birth wt. (kg)	35.4(0.794)[b]	27.2(0.930)[c]	28.4(0.998)[c]	36.5(2.268)[b]
Calf vigor (1-3)	1.0(0.000)	1.0(0.000)	1.0(0.000)	1.0(0.000)
Calving difficulty (1-4)	1.02(0.067)	1.08(0.077)	1.12(0.083)	0.98(0.188)
Gestation length (days)	286.2(0.932)[e]	278.8(1.079)[f]	279.4(1.167)[f]	283.6(2.640)[f]
Retained placenta (24 hrs)	0.053(0.073)[bf]	0.562(0.084)[ebc]	0.762(0.091)[ce]	0.004(0.205)[bf]
Retained placenta (1 week)	0.064(0.079)	0.458(0.091)	0.643(0.099)	0.111(0.223)
Period of gestation at time of injection (days from term)	--	-13 to -4	-14 to -4	-26 to -12

[a] Numbers in parentheses are standard errors. Figure in brackets are actual number of cows treated. All averages are least squares means.

bcd Averages on the same line not having the same superscript differ significantly ($P<.01$).

ef Averages on the same line not having the same superscript differ significantly ($P<.05$).

injection. These cows calved significantly ($P<.01$) later in the year than the successfully treated cows in treatments 2 and 3. Birth weight was decreased in the responding animals when compared to non-responding animals ($P<.01$). Gestation length was shortened ($P<.05$) in those animals being successfully induced as compared to those non-successfully induced. An increase in retention of placental membranes at 24 hrs was found when responding animals were compared to non-responding animals in treatment 2 ($P<.05$) and when all animals in treatment 3 were compared to those non-responding in treatment 2 ($P<.01$). Calf vigor, calving difficulty and retention of placental membranes at one week were not significantly affected when responding animals were compared to those that did not respond to treatment.

The effects of the two antibiotic treatments in treatment 2 for cows with retained placentas were compared statistically. There was a significant ($P<.05$) decrease in the number of cows responding to the induction treatment in the cows injected with long acting antibiotic at time of flumethasone treatment compared to the cows treated with antibiotic at 24 hrs postcalving. No differences could be detected in any other measured parameter.

In the next analysis, the non-induced treated animals were omitted (Table 16). In this comparison the induced animals had a significantly ($P<.01$) earlier birth date, shorter gestation length, higher incidence of retained placenta and lower birth weight of the calves than the controls. There was a significant ($P<.05$) increase in incidence of

TABLE 16. EFFECTS OF FLUMETHASONE (FLU) GIVEN IN A SINGLE INJECTION VS. FLUMETHASONE GIVEN IN TWO INJECTIONS 12 HOURS APART ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION[a] (TRIAL 12)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 10 mg (Flu) double injection
No. cows	34	19 [22]	19 [19]
Birth date (day of year)	248.6(0.927)[b]	241.8(1.071)[c]	242.3(1.158)[c]
Birth wt. (kg)	35.2(0.771)[b]	27.2(0.885)[c]	28.4(0.953)[c]
Calf vigor (1-3)	1.00(0.000)	1.00(0.000)	1.00(0.000)
Calving difficulty (1-4)	1.03(0.068)	1.08(0.078)	1.12(0.084)
Gestation length (days)	286.0(0.918)[b]	278.7(1.060)[c]	279.4(1.146)[c]
Retained placenta (24 hrs)	0.055(0.074)[c]	0.562(0.085)[b]*	0.762(0.092)[b]*
Retained placenta (1 week)	0.065(0.080)[c]	0.458(0.093)[b]	0.642(0.100)[b]
Period of gestation at time of injection (days from term)	--	-13 to -4	-14 to -4
Hours from injection to parturition	--	45.51(4.447)	53.98 (4.946)
Induction success	--	0.886(0.046)	0.980(0.050)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

bc Averages on the same line not having the same superscript differ significantly ($P<.01$).

* These averages differ significantly ($P<.05$).

retained placenta in treatment 3 over treatment 2. Calf vigor and calving difficulty were not affected by treatment. Furthermore, no significant differences were found when treatments 2 and 3 were compared for hours from injection to parturition and induction success.

In trial 13, parturition was induced in 91.7 and 83.3% of the cows in treatments 2 and 3, respectively. An analysis of all animals (Table 17), including unresponsive treated animals, disclosed significant differences for decreased birth weight ($P<.05$) and decreased gestation length ($P<.01$) over the controls but not between the treated groups. No differences between responding and non-responding animals were found when birth date, calf vigor, calving difficulty and retention of placental membranes were compared.

An analysis deleting non-responding animals was then performed (Table 18). In this comparison, animals in treatments 2 and 3 had significantly ($P<.05$) smaller birth weights than those in treatment 1 (control). Calving difficulty was increased in treatment 2 over the controls ($P<.05$) and over treatment 3 ($P<.01$). However, calf vigor was not affected by either treatment. A significant decrease ($P<.01$) in gestation length was found when treatment 2 was compared to treatment 1, but no differences were found when treatment 3 was compared to either treatment 1 or 2. The 24 hr placental check showed significantly increased placental retention in treatment 2 over treatment 1 ($P<.05$) and in treatment 3 over treatment 1 ($P<.01$). There were no significant differences in hours from injection to parturition and induction success between treatments 2 and 3.

TABLE 17. EFFECTS OF TWO DOSE LEVELS OF FLUMETHASONE (FLU) ON COWS AND CALVES AT PARTURITION[a] (TRIAL 13)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 7.5 mg (Flu) single injection	Cows not responding to treatment
No. cows	10	11 [12]	10 [12]	3
Birth date (day of year)	253.1(1.654)	253.6(1.847)	254.3(1.662)	261.7(2.947)
Birth wt. (kg)	34.5(1.270)[ef]	30.6(1.406)[f]	30.2(1.270)[f]	34.7(2.268)[e]
Calf vigor (1-3)	0.962(0.128)	1.227(0.143)	0.902(0.129)	0.898(0.228)
Calving difficulty (1-4)	1.02(0.113)	1.37(0.127)	0.888(0.114)	1.04(0.202)
Gestation length (days)	284.8(1.032)[cb]	280.5(1.153)[c]	282.4(1.037)[c]	287.7(1.840)[b]
Retained placenta (24 hrs)	-0.113(6.150)	0.277(0.168)	0.624(0.151)	-0.111(0.268)
Retained placenta (1 week)	-0.090(0.156)	0.158(0.174)	0.389(0.157)	-0.145(0.278)
Period of gestation at time of injection (days from term)	--	-14 to -3	-8 to -3	-11 to -7

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

[bc] Averages on the same line not having the same superscript differ significantly (P .01).

[ef] Averages on the same line not having the same superscript differ significantly (P .05).

TABLE 18. EFFECTS OF TWO DOSE LEVELS OF FLUMETHASONE (FLU) ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION[a] (TRIAL 13)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 7.5 mg (Flu) single injection
No. cows	10	11 [12]	10 [12]
Birth date (day of year)	253.2(1.751)	253.7(1.969)	254.4(1.769)
Birth wt. (kg)	34.3(1.293)^{e}	30.2(1.429)^{f}	29.9(1.29)^{f}
Calf vigor (1-3)	0.96(0.133)	1.24(0.149)	0.89(1.134)
Calving difficulty (1-4)	1.02(0.113)^{cd}*	1.38(0.127)^{d}*	0.87(0.114)^{c}
Gestation length (days)	284.8(1.079)^{d}	280.4(1.213)^{c}	282.5(1.090)^{dc}
Retained placenta (24 hrs)	-0.132(0.158)^{c}*	0.255(0.178)^{cd}*	0.603(0.160)^{d}
Retained placenta (1 week)	-0.106(0.164)	0.138(0.185)	0.371(0.166)
Period of gestation time of injection (days from term)	--	-14 to -3	-8 to -3
Hours from injection to parturition	--	47.38(6.364)	39.38(4.916)
Induction success	--	1.019(0.128)	0.756(0.131)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

cd Averages on the same line not having the same superscript differ significantly ($P<.01$).

ef Averages on the same line not having the same superscript differ significantly ($P<.05$).

* These averages differ significantly ($P<.05$).

An analysis of all animals in trial 14 (Table 19) showed no significant differences in induction success between treatments 2 and 3. Eighty-nine and 84% of the cows responded to the flumethasone in treatments 2 and 3, respectively. The non-responding animals calved significantly ($P<.01$) later in the year than the responding animals and significantly earlier ($P<.01$) in the year than the controls (Treatment 1). There was a significant decrease ($P<.01$) in birth weight in the responding animals in treatments 2 and 3 as compared to those not responding to treatment. No differences were found when calf vigor and calving difficulty were compared between responding and non-responding groups. Incidence of retained placenta was increased between the responding animals in treatment 2 and the non-responding animals ($P<.01$) and between the responding animals in treatment 3 and the non-responding animals ($P<.05$).

Another statistical analysis was performed which omitted all animals which did not respond to the induction treatments (Table 20). The average birth dates for animals in treatments 2 and 3 were earlier ($P<.01$) in the year than those in treatment 1 (Control). Birth weight was significantly decreased ($P<.01$) in treatments 2 and 3 as compared to the control. In addition, an increase in retention of placental membranes ($P<.01$) was found in the induced treatments over the control. No differences were found when all 3 treatments were compared for calf vigor and calving difficulty. The mean intervals between injection and parturition were 38.26 and 37.99 for treatments 2 and 3, respectively.

TABLE 19. EFFECT OF A.M. VS. P.M. INJECTION OF FLUMETHASONE (FLU) ON COWS AND CALVES AT PARTURITION[a] (TRIAL 14)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) A.M. single injection	Treatment 3 10 mg(Flu) P.M. single injection	Cows not responding to treatment
No. cows	21	33 [37]	32 [38]	10
Birth date (day of year)	271.8(1.120)[b]	262.2(1.044)[c]	262.7(0.941)[c]	266.8(1.372)[d]
Birth wt (kg)	39.9(1.542)[b]	34.0(1.429)[c]	34.5(1.293)[c]	39.7(1.882)[b]
Calf vigor (1-3)	1.000(0.036)	1.03(0.034)	1.00(0.030)	0.99(0.044)
Cavling difficulty (1-4)	0.87(0.173)	1.10(0.161)	1.07(0.146)	1.10(0.212)
Retained placenta (24 hrs)	-0.226(0.144)[c]	0.401(0.135)[be]	0.255(0.121)[de]	-0.086(0.177)[cd]
Retained placenta (1 week)	-0.203(0.141)[cf]	0.243(0.131)[b]	0.190(0.118)[e]	-0.164(0.173)[cf]
Period of gestation at time of injection (days from term)	--	-20 to +9	-20 to +10	-20 to -1

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

[bcde] Averages on the same line not having the same superscript differ significantly ($P < .01$).

TABLE 20. EFFECT OF AN A.M. VS. P.M. INJECTION OF FLUMETHASONE (FLU) ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION[a] (TRIAL 14)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) A.M. single injection	Treatment 3 10 mg (Flu) P.M. single injection
No. cows	21	33 [37]	32 [38]
Birth date (day of year)	271.8(1.181)[b]	262.3(1.103)[c]	262.7(0.994)[c]
Birth wt. (kg)	40.1(1.406)[b]	34.5(1.315)[c]	34.7(1.202)[c]
Calf vigor (1-3)	1.00(0.038)	1.03(0.036)	1.00(0.032)
Calving difficulty (1-4)	0.85(0.175)	1.06(0.164)	1.04(0.147)
Retained placenta (24 hrs)	-.216(0.148)[c]	0.421(0.138)[b]	0.270(0.123)[b]
Retained placenta (1 week)	-.204(0.149)[c]	0.244(0.139)[b]	0.190(0.125)[b]
Period of gestation at time of induction (days from term)	--	-20 to +9	-20 to +10
Hours from injection to parturition	--	38.26(5.33)	37.99(4.780)
Induction success	--	0.956(0.113)	0.899(0.101)

a Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

bc Averages on the same line not having the same superscript differ significantly (P .01).

However, there was a difference (P= .187) in the calving frequencies between 18.00 and 06.00 hrs or 06:00 and 18.00 hrs (Table 21) with 63.6 and 81.2% of the cows in treatments 2 and 3, respectively, calving between 06.00 and 18.00 hrs. No significant differences were found when the treated cows calving in an 8 acre pasture were compared to those treated cows calving in the confines of a corral for calving difficulty and vigor of the calf.

In trial 15 (Table 22) 100% of the animals treated with flumethasone in treatment 2 responded to the injection. Animals in treatment 2 calved 5.7 days earlier in the year ($P<.05$) than those in treatment 1 (Control). No differences were found between treatment groups when birth weight and calf vigor were compared. However, calving difficulty was significantly increased ($P<.05$) in the treated animals over the controls while gestation length was decreased ($P<.01$) in the treated animals when compared to controls. The analysis showed significant increases in retention of placental membranes ($P<.01$) in treated animals over the controls. The average time from injection of flumethasone to parturition was 53.5 hrs for the induced animals.

In trial 16 (Table 23) all flumethasone treated animals were successfully induced, and the treated animals (Treatment 2) calved 10.7 days earlier in the year ($P<.05$) than the controls (Treatment 1). Birth weight was significantly decreased in animals in treatment 2 as compared to those in treatment 1, but no differences were found in any other measured parameter. The average time from injection to parturition

TABLE 21. NUMBER OF CALVINGS OBSERVED DURING THE DAY OR NIGHT AFTER INDUCTION OF PARTURITION WITH 10 MG FLUMETHASONE IN CATTLE

Treatment	No. cows	Time of calving	
		18.00 to 06.00 hrs	06.00 to 18.00 hrs
Treated in A.M.	33	12 (36.4%)	21 (63.6%)
Treated in P.M.	32	6 (18.8%)	26 (81.2%)

TABLE 22. EFFECT OF FLUMETHASONE (FLU) ON TWO-YEAR-OLD HEIFERS AND CALVES AT PARTURITION[a] (TRIAL 15)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection
No. cows	9	9 [9]
Birth date (day of year)	238.2(2.532)*	232.5(3.026)*
Birth wt. (kg)	31.1(0.881)	29.0(1.043)
Calf vigor (1-3)	1.00(0.083)	1.07(0.099)
Calving difficulty (1-4)	1.00(0.133)*	1.46(0.159)*
Gestation length (days)	280.9(1.007)**	275.6(1.204)**
Retained placenta (24 hrs)	0.000(0.107)**	0.857(0.128)**
Retained placenta (1 week)	0.000(0.107)**	0.857(0.128)**
Period of gestation at time of injection (days from term)	--	-12 to -2
Hours from injection to parturition	--	53.5(6.256)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

* These averages differ significantly ($P<.05$)

** These averages differ significantly ($P<.01$)

TABLE 23. EFFFECT OF FLUMETHASONE (FLU) ON TWO-YEAR-OLD HEIFERS AND CALVES AT PARTURITION[a] (TRIAL 16)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection
No. cows	5	7 [7]
Birth date (day of year)	252.9(3.078)*	242.2(2.575)*
Birth wt. (kg)	31.1(0.907)**	27.0(0.771)**
Calf vigor (1-3)	1.0(0.000)	1.0(0.000)
Calving difficulty (1-4)	1.33(0.298)	1.13(0.250)
Gestation length (days)	280.3(1.565)	275.7(1.310)
Retained placenta (24 hrs)	0.250(0.223)	0.458(0.187)
Retained placenta (1 week)	0.000(0.192)	0.292(0.161)
Period of gestation at time of injection (days from term	--	-12 to -4
Hours from injection to parturition	--	43.7(2.811)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

* These averages differ significantly ($P<.05$).

** These averages differ significantly ($P<.01$).

was 43.7 hrs in treatment 2.

A comparison of the induced treatments with the controls in trials 11-14 showed that the flumethasone treated cows took 35 days to complete the calving season as compared to 51 days for the controls (Figure 3). This was a decrease of 16 days in the calving season for the treated cows. An analysis of all animals (Table 24), excluding unresponsive treated animals, in trials 11-14 disclosed significant differences for decreased birth weight and increased retention of placental membranes ($P<.01$) for the flumethasone treated animals over the controls. A significant increase ($P<.05$) in calving difficulty was found when all responding animals in treatment 2 were compared to those animals in treatment 1 (control). However, no difference in calving difficulty was found when the responding animals in treatment 3 were compared to the controls and treatment 2.

A combined statistical analysis of trials 11 and 12, omitting controls were performed to study the effects of gestation length at time of flumethasone injection on the various parameters (Table 25). Gestation length at time of flumethasone injection significantly affected ($P<.05$) retention of placental membranes at 24 hrs and 1 week, and also significantly affected ($P<.01$) vigor of the calf.

The analysis of variance in which calf vigor was regressed on gestation length at time of flumethasone injection (Table 25) indicated that vigor of the calf at birth was not linear in late gestation but that at births prior to 273 days and those past 275 days calf vigor

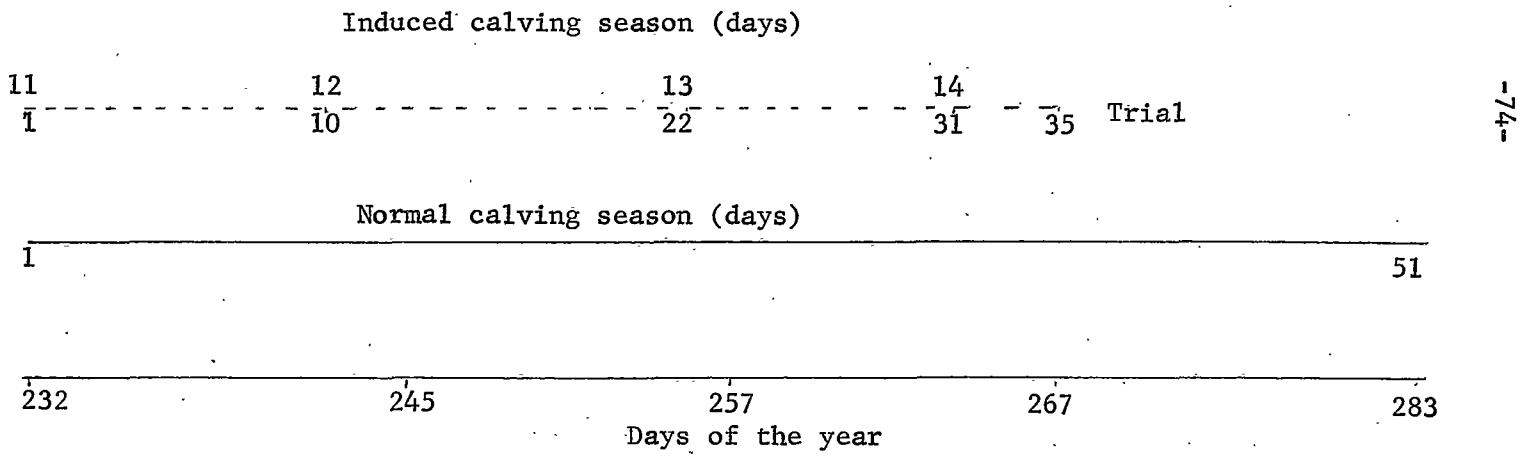


Figure 3. Length of induced calving season as compared to actual length of normal calving season in trials 11-14.

TABLE 24. EFFECT OF FLUMETHASONE (FLU) ON COWS AND CALVES THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION[a] (TRIALS 11 - 14)

Measurement	Treatment 1 Control	Treatment 2 (Flu)	Treatment 3 (Flu)
No. cows	101	75 [84]	82 [90]
Birth date (day of year)	252.7(0.491)[b]	247.6(0.535)[c]	247.4(0.515)[c]
Birth wt. (kg)	35.4(0.522)[b]	30.4(0.589)[c]	30.2(0.544)[c]
Calf vigor (1-3)	0.97(0.026)	1.02(0.029)	0.98(0.027)
Calving difficulty (1-4)	0.97(0.050)*	1.14(0.055)*	1.08(0.053)
Retained placenta (24 hrs)	0.006(0.050)[c]	0.536(0.055)[b]	0.625(0.053)[b]
Retained placenta (1 week)	-.013(0.051)[c]	0.367(0.056)[b]	0.44(0.054)[b]
Period of gestation at time of injection (days from term)	--	-20 to +9	-20 to +10
Hours from injection to parturition	--	45.13(1.681)	46.81(1.616)

a Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

bc Averages on the same line not having the same superscript differ significantly ($P<.01$).

* These averages differ significantly ($P<.05$).

TABLE 25. EFFECT OF FLUMETHASONE ON COWS AND CALVES IN TRIALS 11-12 THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (CONTROLS EXCLUDED)[a]

		Least squares means						
Source	N	Birth date (day of year)	Birth wt. (kg)	Calf vigor (1-3)	Difficulty (1-4)	Retained placenta (24 hrs)	Retained placenta (1 week)	Hours from injection to calving
Trial								
1	32	232.2(0.117)[b]	31.5(0.748)[b]	1.02(0.024)	1.10(0.082)	0.629(0.088)	0.357(0.094)	47.39(2.810)
2	38	242.3(0.102)[c]	28.4(0.658)[c]	1.00(0.021)	1.08(0.072)	0.693(0.077)	0.517(0.082)	50.12(2.447)
Treatment								
2	31	237.2(0.115)	29.7(0.726)	1.00(0.024)	1.07(0.081)	0.607(0.087)	0.409(0.092)	48.37(2.760)
3	39	237.3(0.100)	30.2(0.635)	1.02(0.021)	1.12(0.071)	0.665(0.076)	0.466(0.081)	48.14(2.405)
Sex								
Male	38	237.2(0.100)	30.4(.0635)	1.02(0.020)	1.09(0.070)	0.513(0.075)[e]	0.416(0.080)	46.50(2.395)
Female	32	237.3(0.114)	29.5(0.727)	1.00(0.023)	1.10(0.081)	0.758(0.086)[d]	0.459(0.092)	51.01(2.750)
Sire								
1	12	237.0(0.175)	26.8(1.111)[c]	1.00(0.036)	1.00(0.123)	0.357(0.132)	0.182(0.141)	37.92(4.197)[e]
2	19	237.5(0.152)	30.6(0.975)[b]	1.04(0.031)	1.18(0.108)	0.746(0.115)	0.422(0.123)	53.65(3.663)[d]
3	16	237.2(0.155)	30.2(0.998)[b]	0.99(0.032)	1.10(0.109)	0.746(0.117)	0.666(0.125)	47.53(3.726)[ed]
4	23	237.3(0.125)	32.7(0.816)[b]	1.00(0.026)	1.09(0.883)	0.694(0.095)	0.480(0.101)	53.92(3.011)[d]
Regression on gestation length at time of injection[f]	--	-.0905**	0.2443	0.0016**	-.0077	-.0592*	-.0531*	-1.1713

a Numbers in parentheses are standard errors. All averages are least squares means.

bc Averages on the same line not having the same superscript differ significantly ($P<.01$).

de Averages on the same line not having the same superscript differ significantly ($P<.05$)

f All regression b values are linear except for that of vigor which is quadratic. The regression b value for vigor was analyzed in a model excluding bulls with one more observation.

* $P<.05$.

** $P<.01$.

was decreasing (Figure 4). In the same analysis where retention of placental membranes was regressed on gestation length at time of injection it was found that the number of cows being diagnosed as retained decreased as the cows were treated closer to term. Partial regression coefficients were -.0692 and -.0531 for the partial regressions of retained placenta at 24 hrs (Figure 5) and 1 week (Figure 6) on gestation length at time of injection, respectively.

In a separate analysis again using only flumethasone treated animals in trials 11 and 12 but including non-responding animals, it was found that length of gestation at time of flumethasone injection significantly ($P<.01$) affected induction success (Table 26). The regression of induction success on gestation length at time of injection was linear and indicated that as cows were induced later in gestation an increase in the number of cows responding to the treatment was found (Figure 7).

All responding flumethasone treated animals with accurate or approximated gestation length information in trials 11 through 14 were combined in one analysis to determine the effects of gestation length at time of injection on birth weight, calf vigor, calving difficulty, retention of placental membranes at both 24 hrs and 1 week and hours from injection ot parturition (Table 27). Gestation length at time of flumethasone injection significantly affected birth weight and hours from injection to parturition ($P<.05$), and affected calf vigor and

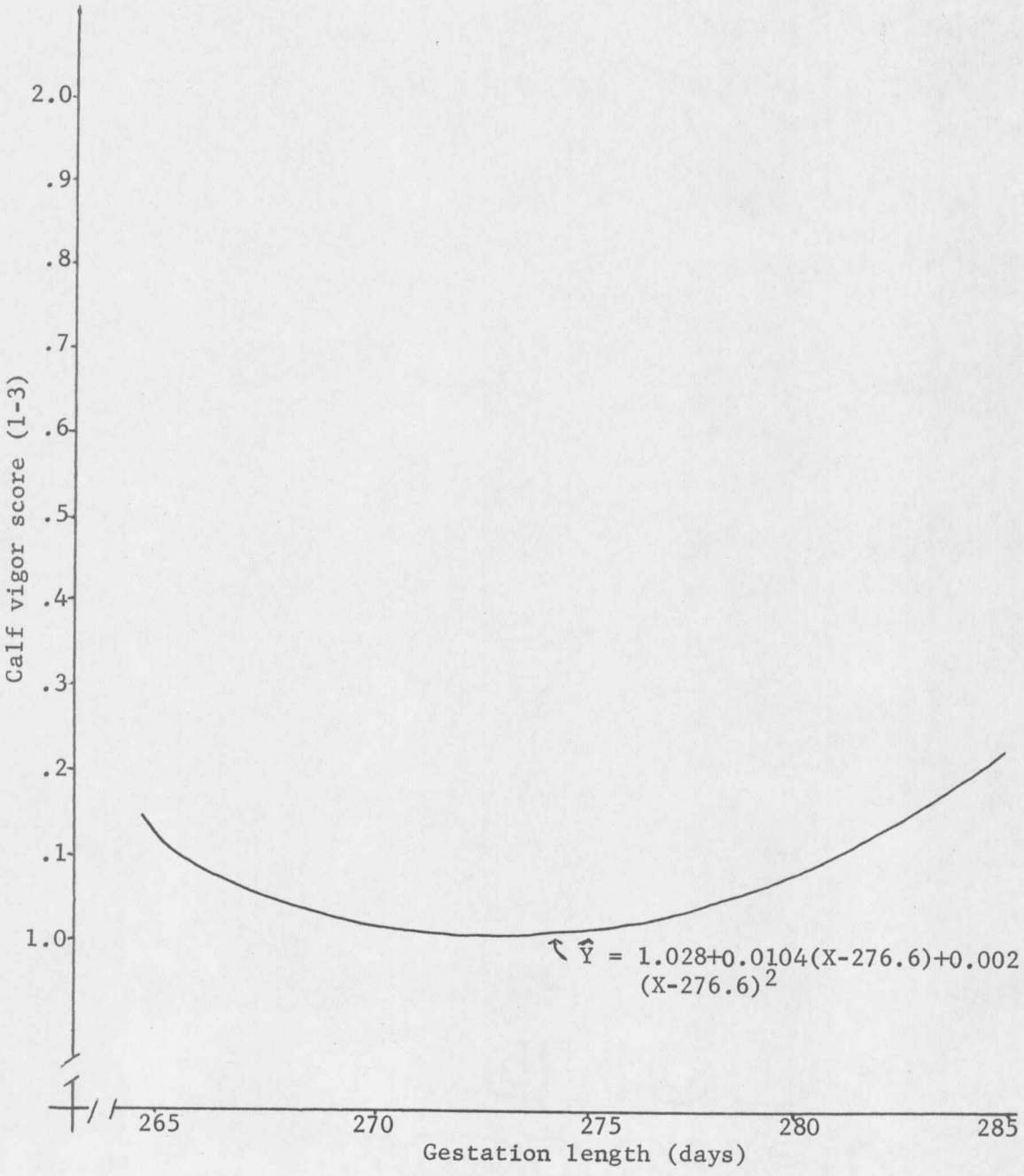


Figure 4. Partial regression of calf vigor score on gestation length at time of injection in cows successfully treated with flumethasone in trials 11-12.

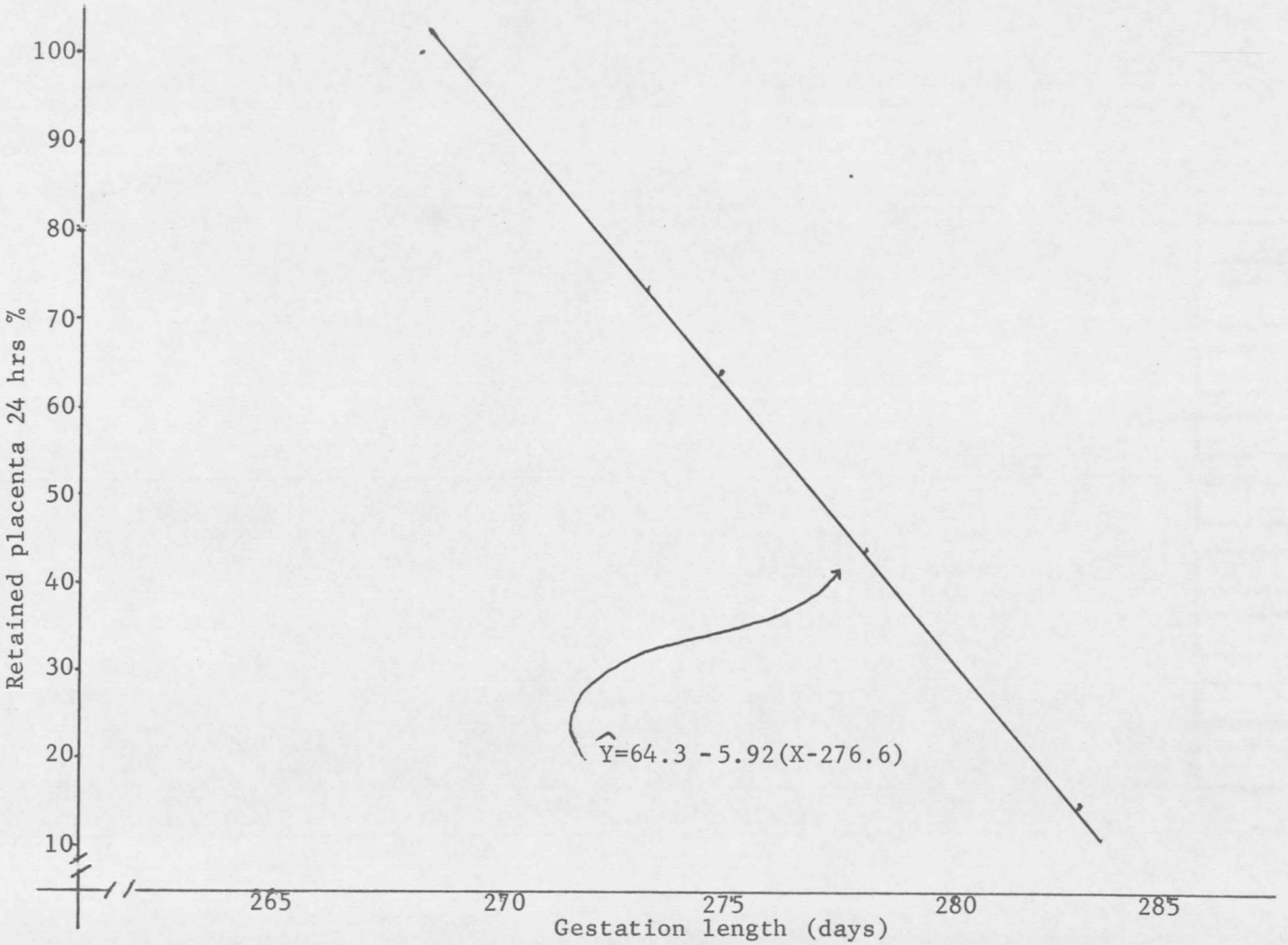


Figure 5. Partial regression of retained placenta at 24 hrs on gestation length at injection in cows successfully treated with flumethasone in trials 11-12.

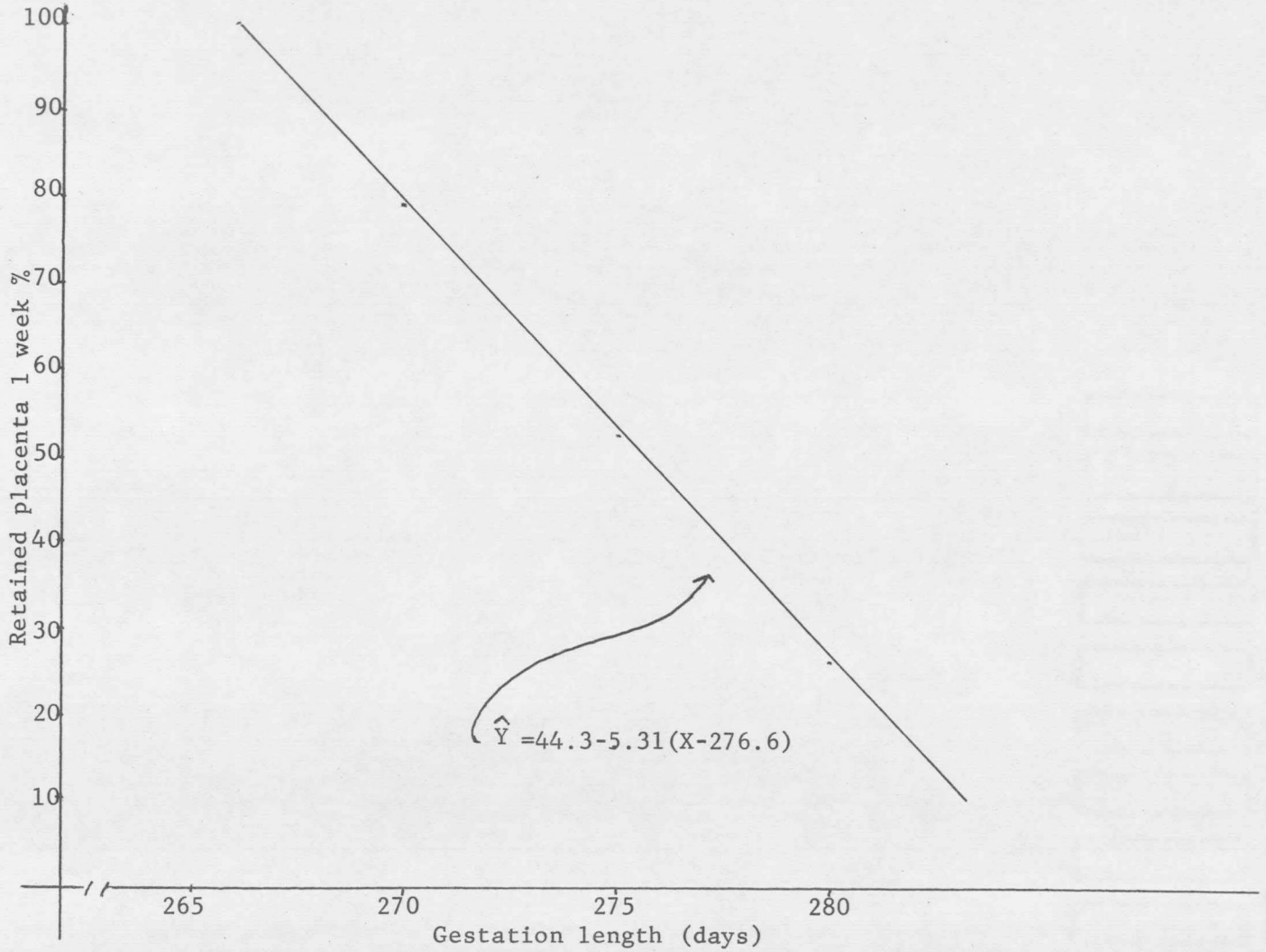


Figure 6. Partial regression of retained placenta at 1 week on gestation length at injection in cows sucessfully treated with flumethasone in trials 11-12.

TABLE 26. EFFECT OF GESTATION LENGTH ON INDUCTION SUCCESS IN COWS TREATED WITH FLUMETHASONE FOR EARLY PARTURITION (CONTROLS NOT INCLUDED)

	Induction success	
	Trial 11-12	Trial 11-14
Mean	$0.946 \pm .228$	$0.887 \pm .318$
Linear regression on gestation length at time of injection[a]	0.0287**	0.0155*

[a] Linear regression b values.
* $P < .05$
** $P < .01$

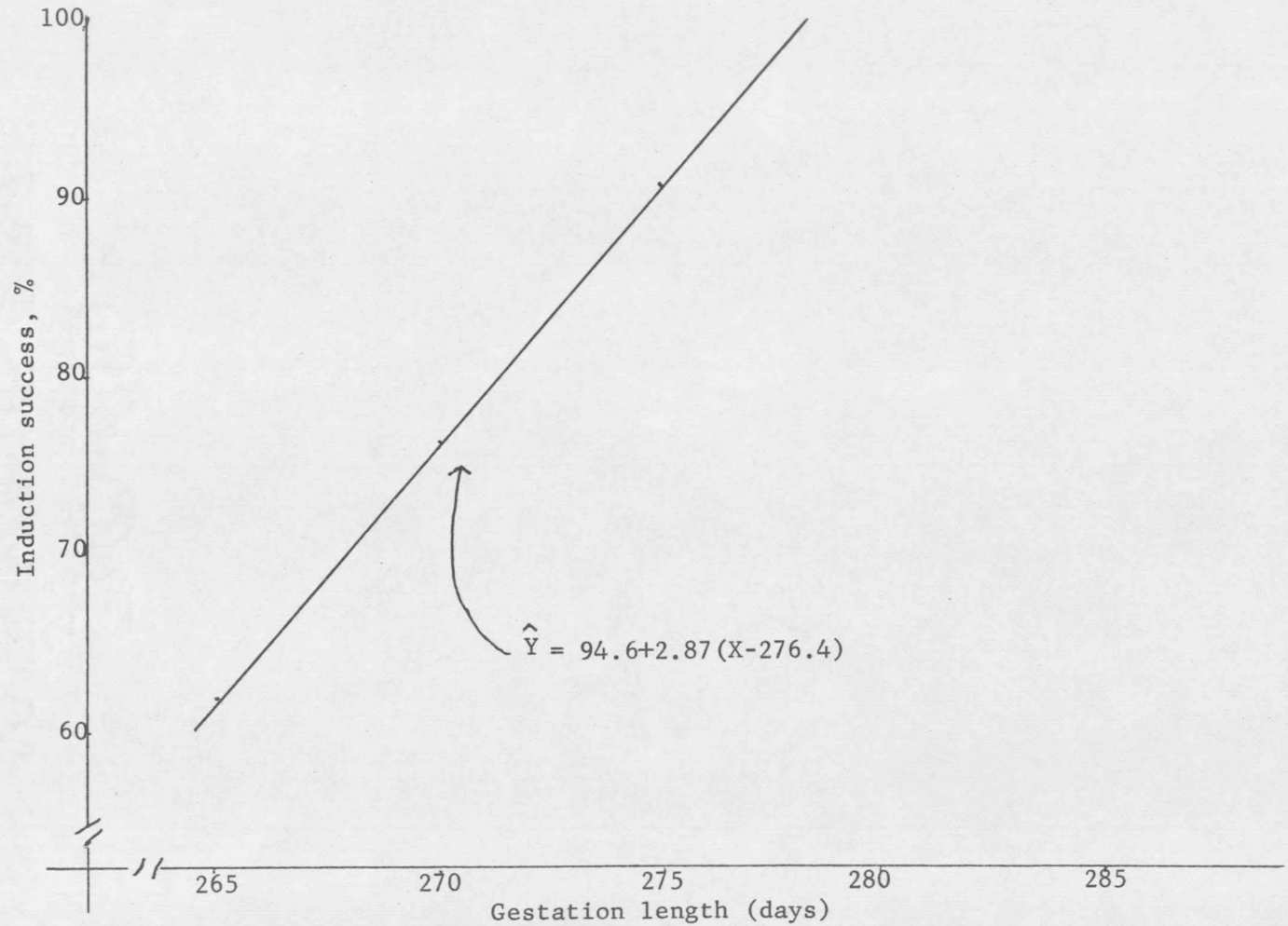


Figure 7. Partial regression of induction success on gestation length at injection in cows successfully treated with flumethasone in trials 11-12.

retention of placental membranes at 24 hrs ($P<.01$).

The analysis of variance in which birth weight was regressed on gestation length at time of injection (Table 27) indicated that growth of the calf was linear in late gestation (Figure 8). Hours from injection to parturition was regressed on gestation length at time of injection also, and showed that as treatment is given closer to term, the amount of time between injection and parturition is decreased linearly (Figure 9). When calf vigor was regressed on gestation length at injection (Table 27) a non-linear relationship was observed which indicated decreased vigor if parturition took place prior to 275 days of gestation in induced cows (Figure 10). One other regression on gestation length at injection was significant. This was retention of placental membranes at 24 hrs. The partial regression coefficient was negative and indicated a decrease in retention of placental membranes as cows were successfully induced closer to term (Figure 11). Hours from injection to calving was also found to have a significant effect on the incidence of retained placenta at 24 hrs after parturition. The partial regression coefficient was 0.0234 ($P<.05$) for the regression of retained placenta at 24 hrs on hours from injection to calving. Standard partial regression coefficients were then calculated to determine which factor was more important in determining placental retention at 24 hrs after parturition. Gestation length at injection was found to be 10 times more important in predicting incidence of

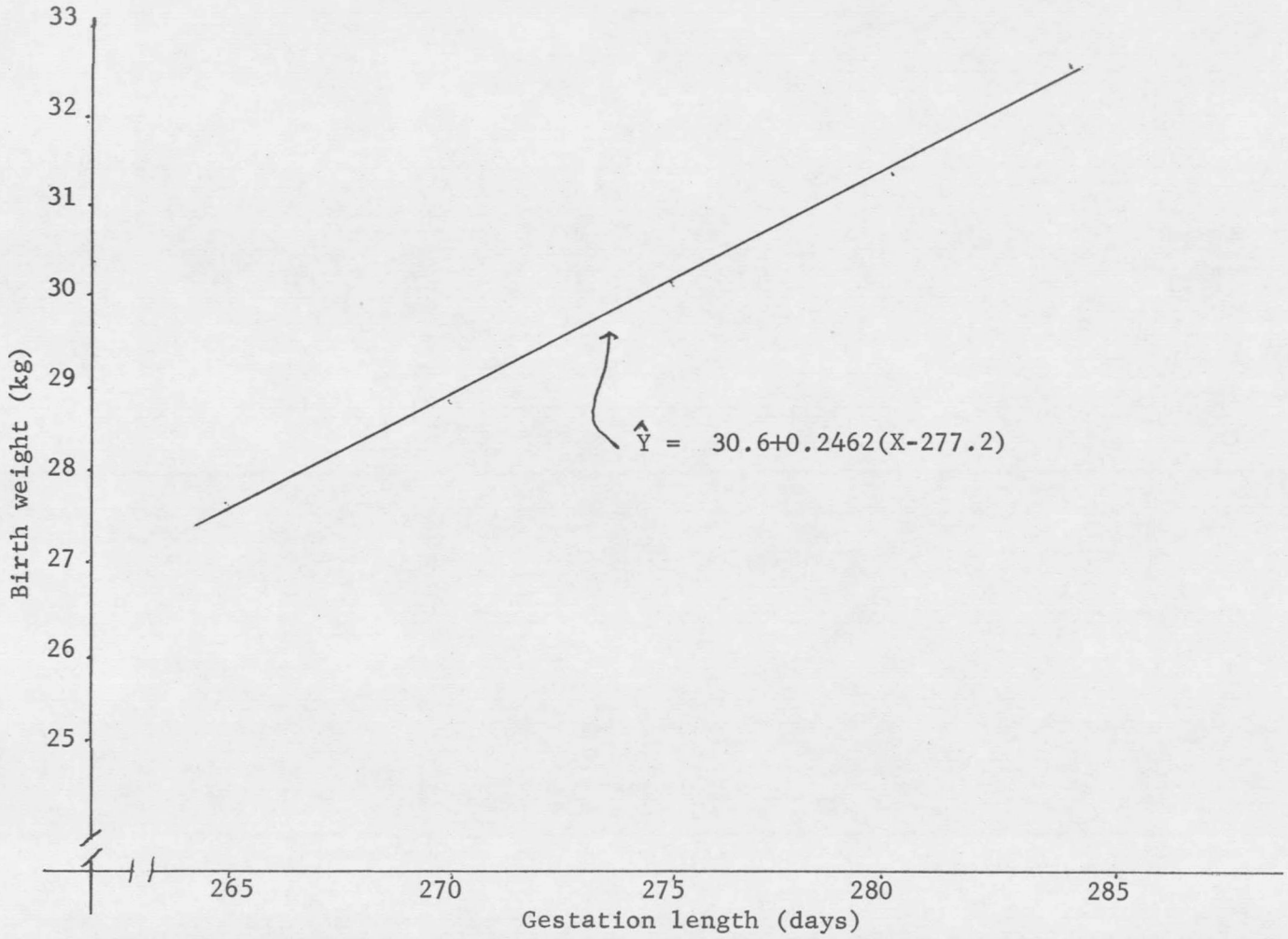


Figure 8. Partial regression of birth weight on gestation length at injection in cows successfully treated with flumethasone in trials 11-14.

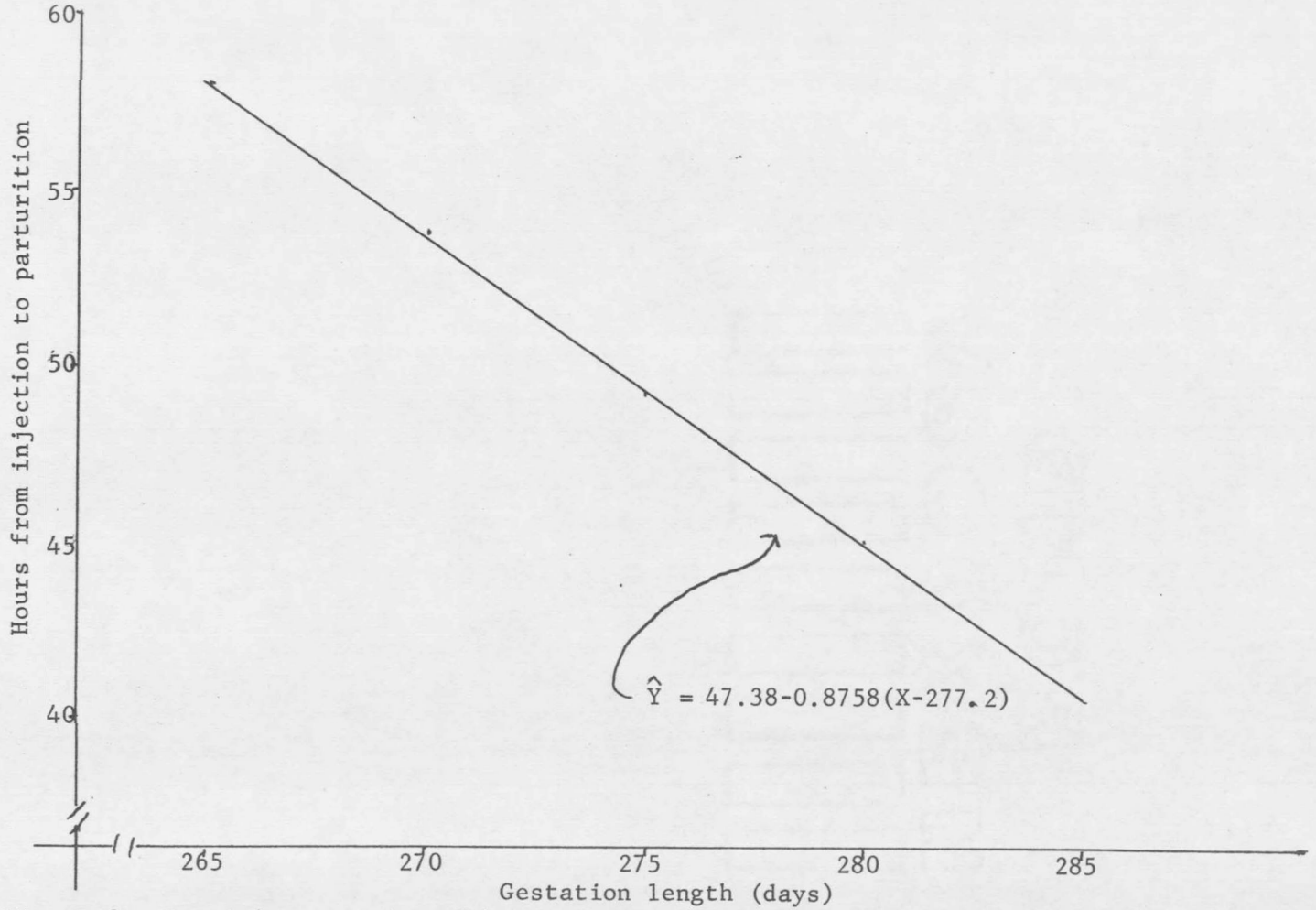


Figure 9. Partial regression of hours from induction to parturition on gestation length at injection in cows successfully treated in trials 11-14.

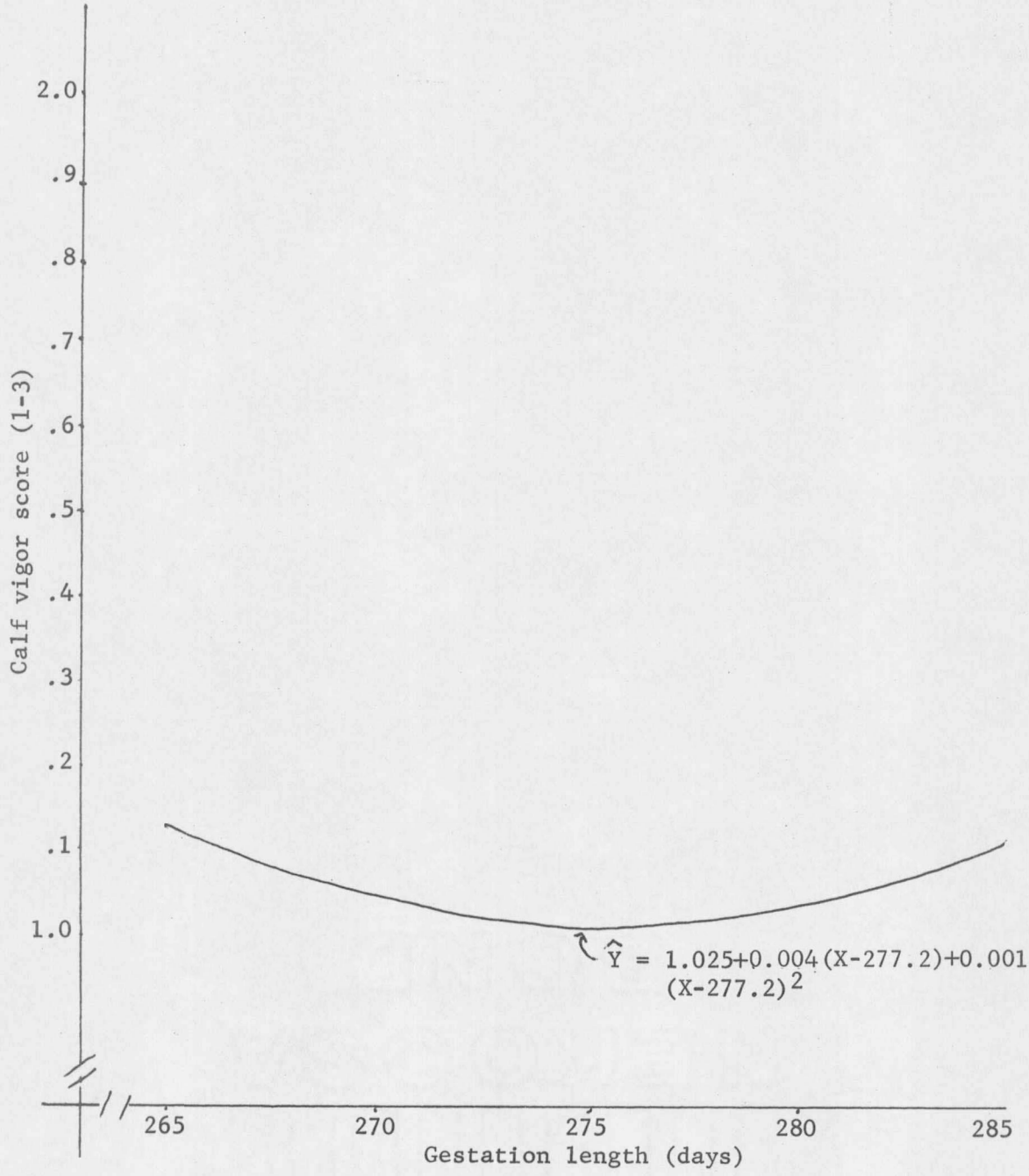


Figure 10. Partial regression of calf vigor score on gestation length at time of injection in cows successfully treated with flumethasone in trials 11-14.

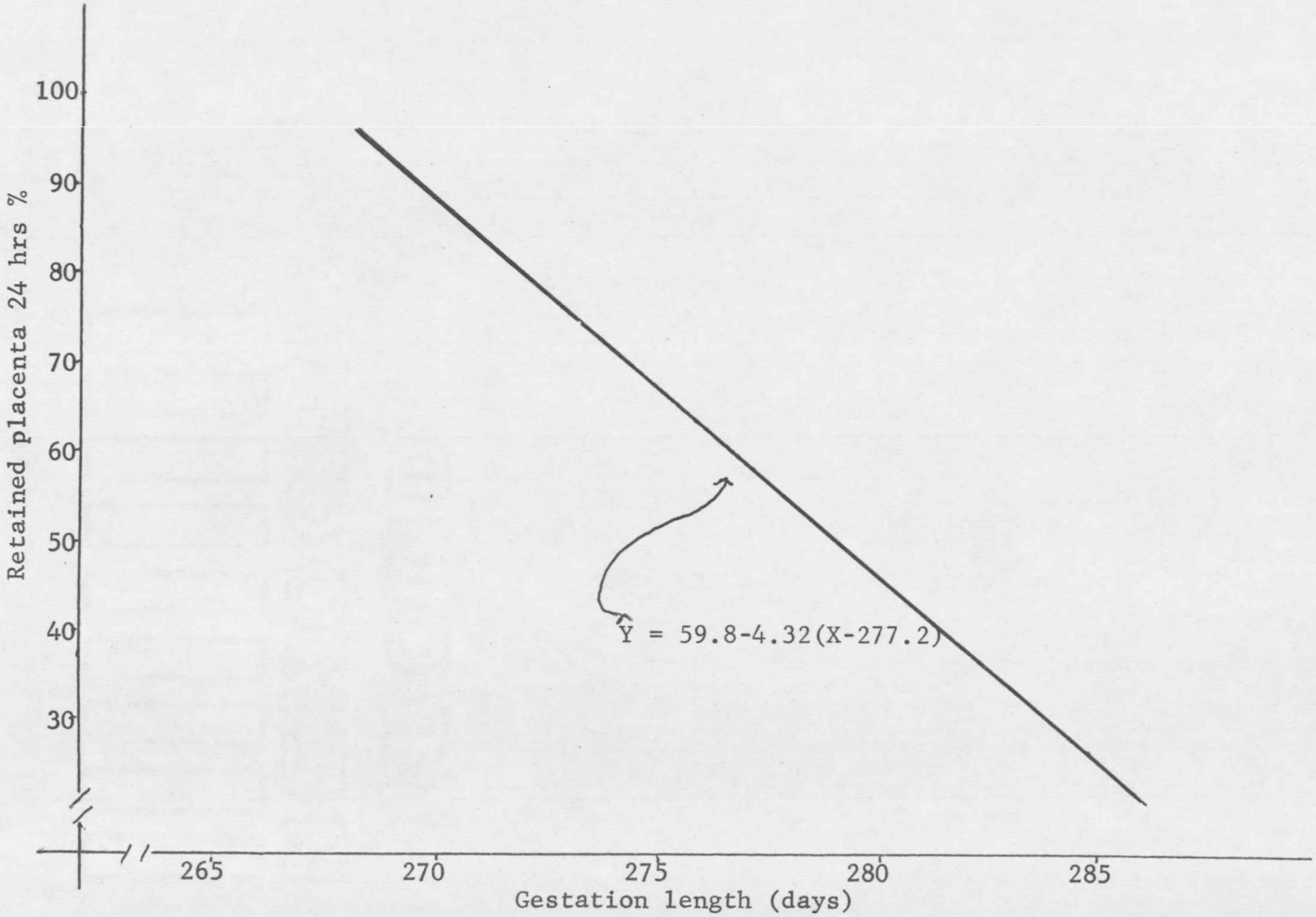


Figure 11. Partial regression of retained placenta at 24 hrs on gestation length at injection in cows successfully treated with Flumethasone in trials 11-14.

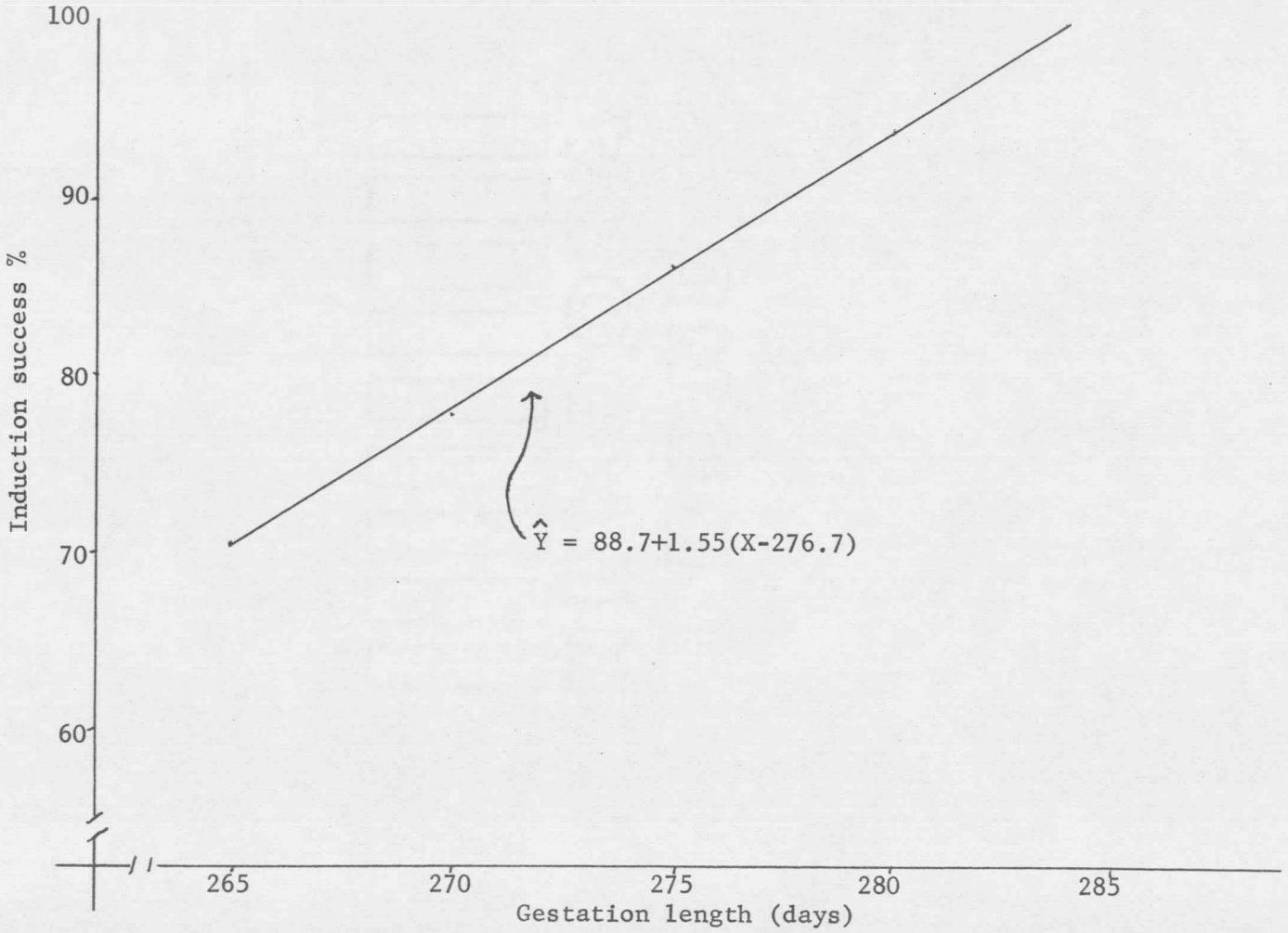


Figure 12. Partial regression of induction success on gestation length at injection in cows successfully treated with flumethasone in trials 11-14.

TABLE 27. EFFECT OF FLUMETHAZONE ON COWS AND CALVES IN TRIALS 11-14 THAT RESPONDED TO THE TREATMENT WITH EARLY PARTURITION (CONTROLS EXCLUDED)[a]

Source	N	Least squares means: Birth date (day of year)	Birth wt. (kg)	Calf vigor (1-3)	Difficulty (1-4)	Retained placenta (24 hrs)	Retained placenta (1 week)	Hours from injection to calving
Trial [b]								
1	33	232.2(0.143)[c]	30.8(0.816)[d]	1.10(0.045)[c]	1.12(0.083)	0.572(0.100)	0.335(0.108)	47.17(3.300)
2	38	242.2(0.125)[d]	27.4(0.726)[d]	1.05(0.040)[c]	1.11(0.073)	0.613(0.088)	0.490(0.095)	50.19(2.899)
3	21	254.1(0.153)[e]	30.4(0.862)[d]	1.09(0.048)[c]	1.13(0.089)	0.587(0.107)	0.455(0.116)	45.24(3.531)
4	26	262.9(0.260)[f]	34.2(1.497)[c]	0.82(0.082)[d]	0.98(0.152)	0.650(0.182)	0.473(0.197)	42.99(6.008)
Treatment								
2	56	247.8(0.106)	30.6(0.590)	1.02(0.034)	1.11(0.062)	0.573(0.074)	0.411(0.080)	46.35(2.443)
3	62	248.0(0.099)	30.8(0.567)	1.01(0.031)	1.06(0.058)	0.638(0.069)	0.464(0.075)	46.44(2.286)
Sex								
Male	66	247.8(0.090)	31.3(0.522)	0.99(0.029)	1.04(0.052)	0.494(0.063)[n]	0.381(0.068)	43.06(2.075)[n]
Female	52	248.0(0.107)	30.2(0.612)	1.04(0.034)	1.12(0.063)	0.718(0.075)[m]	0.495(0.081)	49.74(2.484)[m]
Sire								
1	16	247.6(0.190)	29.0(1.089)[dm]	0.94(0.060)	1.05(0.111)	0.369(0.134)	0.247(0.144)	37.97(4.388)
2	28	248.1(0.150)	32.2(0.862)[c]	1.01(0.048)	1.12(0.088)	0.652(0.105)	0.421(0.113)	50.62(3.477)
3	17	247.8(0.199)	31.9(1.134)[c]	0.95(0.063)	1.06(0.116)	0.722(0.139)	0.667(0.151)	44.27(4.598)
4	29	248.0(0.150)	34.0(0.862)[c]	0.94(0.048)	1.03(0.088)	0.704(0.105)	0.498(0.114)	50.61(3.477)
5	28	247.9(0.226)	26.3(1.293)[dn]	1.23(0.072)	1.15(0.132)	0.580(0.158)	0.408(0.171)	48.52(5.219)
Regresssion on gestation length at time of injection[b]		-.0436*	0.2462*	0.0010**	-.0035	-.0432**	-.0230	-.8758*

a Numbers in parentheses are standard errors. All averages are least squares means.

b All regression b values are linear except for that of vigor which is quadratic.

cdef Averages on the same line not having the same superscript differ significantly ($P<.01$).

mn Averages on the same line not having the same superscript differ significantly ($P<.05$).

* $P<.05$.

** $P<.01$.

In the next analysis, all treated animals (responding and non-responding) with accurate or approximated gestation lengths in trials 11 through 14 were used to determine the effect of gestation length at time of flumethasone injection on induction success (Table 26). The regression of induction success on gestation length at time of injection was significant ($P<.05$) and linear (Figure 12).

In trial 11 (Table 28) no significant differences were found when pregnancy rate at the end of the 45 day breeding season and fertility score for the first 25 days of breeding were compared across the three treatments. Pregnancy rates were 0.816, 0.940 and 0.802 for treatments 1, 2 and 3, respectively, with the non-responding animals having a rate of 0.950.

In trial 12 (Table 29) pregnancy rates after the 45 day breeding season were 0.860, 0.920 and 0.723, and fertility scores for the first 25 days of breeding were 1.15, 1.18 and 0.606 for treatments 1, 2 and 3, respectively. There were no statistically significant differences between groups when compared.

Trial 13 (Table 30) showed pregnancy rates of 0.446, 0.446 and 0.608 for treatments 1, 2 and 3, respectively, while the 3 cows not responding to the induction treatments had a pregnancy rate of 0.970. Again none of the measured parameters were significantly different when compared across groups.

There were no significant differences in reproductive performance between the three treatment groups in trial 4 (Table 31) as measured

TABLE 28. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) IN A SINGLE INJECTION VS. FLUMETHASONE IN TWO INJECTIONS 12 HOURS APART[a] (TRIAL 11)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 10 mg (Flu) double injection	Cows not responding to treatment
No. cows	36	11 [13]	20 [21]	2
Pregnant after 45 day breeding season	0.816(0.079)	0.940(0.115)	0.802(0.086)	0.950(0.263)
Fertility score first 25 days of breeding	1.23(0.189)	0.946(0.275)	0.928(0.204)	0.996(0.627)

a Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

TABLE 29. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) IN A SINGLE INJECTION VS. FLUMETHASONE IN TWO INJECTIONS 12 HOURS APART[a] (TRIAL 12)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 10 mg (Flu) double injection	Cows not responding to treatment
No. cows	32	15 [22]	18 [19]	3
Pregnant after 45 day breeding season	0.860(0.081)	0.920(0.101)	0.763(0.100)	1.03(0.212)
Fertility score first 25 days of breeding	1.15(0.191)	1.18(0.101)	0.606(0.238)	1.17(0.502)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

TABLE 30. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) AT TWO DIFFERENT DOSE LEVELS[a] (TRIAL 13)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection	Treatment 3 7.5 mg (Flu) single injection	Cows not responding to treatment
No. cows	10	10 [12]	9 [12]	3
Pregnant after 45 day breeding season	0.446(0.176)	0.446(0.176)	0.608(0.186)	0.970(0.305)
Fertility score first 25 days of breeding	1.24(0.251)	0.642(0.251)	1.28(0.265)	0.741(0.435)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

TABLE 31. SUBSEQUENT FERTILITY OF COWS RECEIVING FLUMETHASONE (FLU) IN AN A.M. INJECTION VS. P.M. INJECTION[a] (TRIAL 14)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) A.M. single injection	Treatment 3 10 mg (Flu) P.M. single injection	Cows not responding to treatment
No. cows	19	29 [37]	30 [38]	10
Pregnant after 45 day breeding season	0.843(0.096)	0.891(0.084)	0.727(0.078)	0.694(0.134)
Fertility score first 25 days of breeding	0.906(0.198	0.777(0.174)	1.12(0.161)	0.642(0.277)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

by pregnancy rate after a 45 day breeding season and average fertility score for the first 25 days of breeding. Pregnancy rates were 0.843, 0.891 and 0.727 and fertility scores were 0.906, 0.777 and 1.12 for treatments 1, 2 and 3, respectively. The non-responding cows in trial 14 treatments 2 and 3, showed a pregnancy rate of 0.694 and fertility score of 0.642.

In trial 15 (Table 32), again there were no significant differences between groups when measured by pregnancy rate and fertility score.

In trail 16, (Table 33), the pregnancy rates after the 45 day breeding season were 0.80 and 0.857 and the fertility scores for the first 25 days of breeding were 0.600 and 1.43 for treatments 1 and 2, respectively. No significant differences were found.

In a subsequent analysis all cows in trials 11 through 14 (non-responding omitted) were combined to compare subsequent fertility of the treatments (Table 34). Pregnancy rates after the 45 day breeding season were 0.741, 0.794 and 0.707 and fertility scores were 1.13, 0.888 and 0.982 for treatments 1, 2 and 3, respectively. There were no significant differences between groups in the above analysis.

The effect of retention of placental membranes at 24 hrs and 1 week on subsequent fertility was determined in an analysis where all cows, excluding non-resonding animals, in trials 11 and 12 were combined (Table 35). The effect of gestation length at time of flumethasone injection on fertility was also determined in this analysis.

TABLE 32. SUBSEQUENT FERTILITY OF HEIFERS RECEIVING FLUMETHASONE (FLU)[a] (TRIAL 15)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection
No. cows	9	9[9]
Pregnant after 45 day breeding season	0.889(0.111)	0.889(0.111)
Fertility score first 25 days of breeding	1.22(0.317)	1.11(0.317)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual numbers of cows treated. All averages are least square means.

TABLE 33. SUBSEQUENT FERTILITY OF HEIFERS RECEIVING FLUMETHASONE (FLU)[a] (TRIAL 16)

Measurement	Treatment 1 Control	Treatment 2 10 mg (Flu) single injection
No. cows	5	7 [7]
Pregnant after 45 day breeding season	0.800(0.182)	0.857(0.154)
Fertility score first 25 days of breeding	0.600(0.422)	1.430(0.357)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual numbers of cows treated. All averages are least squares means.

TABLE 34. SUBSEQUENT FERTILITY OF ALL COWS RESPONDING TO TREATMENT WITH FLUMETHASONE (FLU)[a] (TRIALS 11-14)

Measurement	Treatment 1 Control	Treatment 2 (Flu)	Treatment 3 (Flu)
No. cows	97	65 [84]	78 [90]
Pregnant after 45 day breeding season	0.741(0.049)	0.794(0.056)	0.717(0.053)
Fertility score first 25 days of breeding	1.13(0.102)	0.888(0.116)	0.982(0.109)

[a] Numbers in parentheses are standard errors. Figures in brackets are actual number of cows treated. All averages are least squares means.

Pregnancy rates were 0.880 and 0.795 and fertility scores were 0.872 and 1.09 for cows without a retained placenta and those with a retained placenta, respectively, at 24 hrs after parturition. At 1 week, the pregnancy rates were 0.817 and 0.858 and the fertility scores were 1.09 and 0.872 for cows without a retained placenta and those with a retained placenta, respectively. No differences in reproductive performance were found. Gestation length at time of injection of flumethasone showed no significant effect on subsequent fertility.

Another statistical analysis was performed which used all cows in trials 11 through 14 except those not responding to treatment to measure the effects of retention of placental membranes on pregnancy rate after the 45 days breeding season and fertility score for the first 25 days of breeding (Table 35). There were no differences in pregnancy rate or fertility score between cows with a retained placenta at 24 hrs or without. There was also no difference in pregnancy rate or fertility score between cows having a retained placenta at 1 week and those not having any placental retention. Pregnancy rates were 0.786, 0.701, 0.744 and 0.743 and fertility scores were 0.867, 1.03, 1.08 and 0.815 for those animals without a retained placenta at 24 hrs, with a retained placenta at 24 hrs, without a retained placenta at 1 week and with a retained placenta at 1 week, respectively.

Sex of calf significantly affected ($P<.01$) birth weight in trials 11-14. Cows with female calves had significantly ($P<.01$) more calving difficulties than those with male calves in trial 13. This

TABLE 35. EFFECT OF GESTATION LENGTH AT TIME OF PARTURITION AND RETENTION OF PLACENTAL MEMBRANES AT 24 HOURS AND 1 WEEK AFTER PARTURITION ON SUBSEQUENT FERTILITY OF COWS SUCCESSFULLY TREATED WITH FLUMETHASONE[a]

	Least squares means				
	Trials 11-12		Trials 11-14		
Source	N	Pregnant after 45 day breeding season	Fertility score first 25 days of breeding	N	Pregnant after 45 day breeding season	Fertility score first 25 days of breeding
Retained placenta[c] (24 hrs)						
0	91	0.880(0.085)	0.872(0.198)	157	0.786(0.064)	0.867(0.132)
1	42	0.795(0.071)	1.09(0.166)	83	0.701(0.056)	1.03(0.114)
Retained placenta[c] (1 week)						
0	104	0.817(0.062)	1.09(0.143)	181	0.744(0.048)	1.08(0.098)
1	29	0.858(0.090)	0.872(0.210)	59	0.743(0.069)	0.815(0.143)
Linear regression on gestation length at time of parturition[b]	--	-.013	-.020	--	--	--

a Numbers in parentheses are standard errors. All averages are least squares means.
b Linear regression b values.
c 0 = not retained, 1 = retained.

was not found in any other trial. In a combination of all cows in trials 11-14, heifer calves were less vigorous at birth than male calves ($P<.05$), however, this relationship was not found in any one trial when analyzed individually. When only successfully induced cows were analyzed from trials 11-14, cows giving birth to heifer calves took a significantly longer interval from injection to parturition ($P<.05$) and at 24 hrs after calving had a higher incidence of retained placenta ($P<.05$) than those cows having bull calves. Although these sex effects on hours from injection to calving and retention of placental membranes at 24 hrs were not significant when the data were analyzed for each individual trial; cows with heifer calves had consistently longer intervals from injection to calving in trials 11, 13 and 14, and had a higher incidence of retained placenta at 24 hrs in trials 11, 12 and 13 than cows with bull calves.

Sires showed a significant effect on birth date, birth weight and gestation length in trials 11-14 ($P<.01$). They also significantly ($P<.01$) affected vigor when all cows from trials 11 through 14 were analyzed together.

The previous years treatment showed no effect on any measured parameter in the 1973 fall calving season.

DISCUSSION

Fall calving, 1972

The different routes of administration (intravenously vs. intramuscularly) of dexamethasone in trial 1 did not show any significant differences when compared for all measured parameters except calving difficulty. This difference could only be attributed to the small numbers involved. Carroll (1974) reported no difference in total response in heifers treated with flumethasone by the intravenous vs. intramuscular route which confirms the above data. In contrast to these data, an earlier field report had indicated only small amounts of retained placenta when the corticosteroid was injected intravenously. However, it was later determined that an oral form of the corticosteroid had been used in the above report. J. N. Wiltbank (personal communication) found an increase in stillborn calves and a decrease in vigor of the live calves when a corticosteroid compound manufactured for oral use was given intravenously. The dexamethasone given either I.M. or I.V. in trial 1 evinced similar results for induction success and retained placenta to that reported by Adams (1969) and Adams and Wagner (1970) in their experiments using 20 mg of dexamethasone (I.M.).

Osinga et al. (1971) attempted to decrease retained placenta by giving a large dose of flumethasone orally which would assure a longer lasting effect. No decrease in retained placenta was found. However, W. C. Wagner (personal communication) revealed a possible increase in

induction success and decrease in retained placenta if the corticosteroid was injected in two installments 24 hrs apart as compared to just one injection. This contention was further supported by field reports showing very little retained placenta when flumethasone was given in two injections 12 hrs apart. In trials 2 and 3, dexamethasone was administered in 2 injections 24 hrs apart using various dose levels and two methods of injection (intravenous and intramuscular). At 24 hrs after parturition 35, 29.4, 37.5 and 23.8% of the cows in treatments 2 and 3, trial 2, and treatments 2 and 3, trial 3, respectively, were diagnosed as having retained placentas. The percentage of animals responding to treatments 2 and 3, trial 2, were 95.2 and 94.4%, respectively, and all animals responded to the dexamethasone injections in trial 3. The herein reported figures for retained placenta are much lower than the expected 80% reported by Jöchle (1971). Adams and Wagner (1970) reported that 50% of the cows in which parturition was induced in their study had retained fetal membranes. Both of the above studies showed a higher incidence of retained placenta than in trials 2 and 3. The population of heifers and cows worked with in these two trials were the last animals due to calve in the calving season. They tended to show a large variation in their expected parturition date. The fact that many of these heifers and cows were close to normal term could account for the small incidence of retained placenta. There was also no significant

differences in birth weight between controls and treated animals, which indicates that a high percentage of these cows were close to term at injection. This would be consistant with the significant correlation of birth weight with day of pregnancy at parturition as reported by Wagner et al. (1974a) Carroll (1974) reported that the lowest frequency of retained placenta is near term, and increases as you induce earlier in gestation. Furthermore, Bosc (1971) demonstrated a better response to the corticosteroid as it is injected closer to normal term. On the other hand, Welch et al. (1973) reported that long acting corticosteroids when used for induction do not show a high incidence of retained placenta. The split dosage of dexamethasone giving two peaks of corticosteroid on consecutive days could account for the decreased placental problem. However, Wagner (1972) did not report this effect when 2 injections of dexamethasone were given 24 hrs apart.

Adams and Wagner (1970) hypothesized that the mechanism for parturition becomes more sensitive as the fetus approaches maturity. This could possibly explain the high success rate obtained in trials 2 and 3. Furthermore, the combined dosages used in trials 2 and 3 were higher than those used by LaVoie and Moody (1973a) who reported a success rate of approximately 75%. Jöchle (1971) stated that larger dose levels of corticosteroids are required in earlier phases of the gestation period for better success. Wagner (1972) showed that 30 mg dexamethasone was apparently necessary for best results. In his work,

total dose seemed to be the most important criteria for a high success rate, not whether the dose was given in two injections.

All of the animals which did not respond to the induction treatment were either allowed to calve normally or retreated with dexamethasone. These animals which failed to induce on first treatment were successfully induced by the second treatment which indicates that a second treatment of cows which failed to induce on first treatment can be used as a management tool. Also, this part of the experiment indicated that cows which did not respond to the induction treatment will calve normally if not retreated.

Administration of dexamethasone had no significant effect on subsequent fertility in trials 1, 2 and 3. This is consistent with LaVoie and Moody (1973b) who found no significant difference between controls and dexamethasone induced cows for first service conception rate, conceptions per service, pregnancy rate and the time during the breeding season when estrus and conception occurred. However, it is interesting to note that in trial 1, treatment 3 showed a 15% higher pregnancy rate and a higher fertility score than controls. In trials 2 and 3, the controls had 3 and 12 days, respectively, more time to prepare for breeding.

A comparison of controls and dexamethasone induced calves showed no significant differences in subsequent calf performance. Nevertheless, in trial 1, treatment 3 showed a 3.7 kg advantage over the

control for actual weaning weight, and a 20.6 kg advantage in kg of calf weaned per cow successfully treated. Furthermore, in trial 2, treatments 2 and 3 demonstrated an increase of 9.2 and 13.7 kg, respectively, in actual weaning weight over the non-induced control. However, in trial 3, the control showed an advantage over the treated animals in all parameters measured except kg of calf weaned per cow successfully treated.

LaVoie and Moody (1973b) reported similar weights for controls and dexamethasone induced calves during lactation and at weaning. This data were confirmed by Carroll (1974) who showed no significant differences between induced calves and controls. In this stage, it does not appear that induced calving has a deleterious effect on subsequent calf performance.

Fall calving, 1973

The results obtained in beef cows after treatment with a sufficient dose of flumethasone during late gestation show that parturition may be induced at a predetermined time. This is consistent with work reported by Jöchle (1971), Carroll (1974) and Wiltbank (1973). Flumethasone given in a 10 mg dose at a single injection or in two 5 mg doses 12 hrs apart will induce precocious parturition in a very high percentage of cows treated during the last 2 weeks of gestation. Cows not responding to treatment in trials 11 through 13 were treated anywhere from 7 to 26 days before estimated gestation. The fact that

these animals did not induce was probably due to their stage of gestation at treatment. This is consistent with work reported by Adams and Wagner (1970) where cows treated earlier in gestation with corticosteroids have a smaller success rate than those treated close to term.

In trial 12, treatment 2 was responsible for all 3 non-responding animals in the trial. These non-responding animals were treated 2 to 3 weeks prior to expected term, and this early treatment could be the sole reason for not responding. However, half of the animals in treatment 2 (trial 12) were injected at time of flumethasone treatment with long acting antibiotic, and these cows accounted for all of the non-responding animals. Whether the long acting antibiotic was the reason for the decrease in success or not is unknown at this time.

The induction success in trial 14 was less than in trials 11-13, however, not significantly less. This decrease is possibly due to the fact that some cows were injected an estimated 20 days prior to term. Bosc (1971) demonstrated that response to the treatment varied with the amount injected and the day of pregnancy. This report possibly confirms the idea that the reason for the decreased response was the early stage of gestation. Neverthe,less, these cows were also injected with long acting antibiotic at time of flumethasone treatment and this could have had an effect on the response.

All the heifers in trials 15 and 16 responded to treatment with flumethasone. This is not consistent with claims made that heifers

may respond less consistently to certain corticoids as compared to cows (Jöchle, 1971).

In all trials except 13, induced cows were born significantly earlier in the year than the controls and non-responding animals. In only trial 14 were the non-responding cows born significantly ($P<.01$) earlier in the year than the controls. Non-responding animals calved normally or were reinduced with no apparent problems. This confirms the Fall, 1972 data reported earlier, and confirms the idea that cows not responding to first treatment can be reinjected as a management tool. Carroll (1974) recommended the reinjection of all animals not successfully induced in a prior trial as a management practice.

The induction of parturition in beef cows and heifers and flumethasone caused a significant decrease in birth weight, decrease in gestation length where applicable and an increase in retained placenta when induced animals were compared with controls. This is consistent with most studies reviewed by Jöchle (1971) and Carroll (1974). No significant differences were found between control and induced calves for vigor.

However, the scoring system used in estimating vigor should be improved, if possible, to remove the variation involved with an subjective measurement. Also, another vigor measurement should be taken on the calf approximately 24 hrs after parturition to estimate postnatal vigor. In this study, induced calves required more

postnatal care than the control calves. This included an increase in the number of calves having to be manually assisted in the first suckling attempts. A reason for this increase in postnatal care is not wholly evident, but the fact that most of the induced calves were calved in the confinement of a corral while controls were calved outside could be a direct cause. A large number of cows calving over a short period in a small area was the source of a considerable amount of confusion to the cows and calves when it came to mothering up the pairs. In trial 14, an attempt was made to compare induced calving in a small corral with induced calving in an 8 acre pasture. No differences in measured parameters were found, but an error was made in that the vigor scoring system was not altered. Wagner et al. (1974a) recommended that help be available for suckling induced calves, and Carroll (1974) reported a decrease in vigor in one study involving Charolais cows. These observations indicated a problem with calf vigor in induced cows. On the otherhand, most observations for vigor in induced calves show good viability (Jöchle, 1971; Beardsley et al., 1973; LaVoie and Moody, 1973a). One must remember, however, that as you induce earlier in gestation a lower calf viability is expected (Carroll, 1974).

Carroll (1974) reported that in one Charolais herd, there was a high death loss of calves induced on day 270 during the first 50 days after parturition. In this particular herd, the controls had normal gestation lengths of approximately 290 days. The author

concluded that the optimum time for induction could depend on the genotype of the fetus. In trials 11 through 13 where accurate breeding data were available, sires demonstrated a significant effect on gestation length ($P<.01$). They also manifested a significant effect on hours from flumethasone treatment to parturition ($P<.05$) in the statistical analysis combining trials 11 and 12. Sire 1 displayed the shortest gestation lengths in his calves ($P<.01$), and cows carrying his progeny had the shortest duration from induction treatment to calving ($P<.05$). This sire also demonstrated a significantly lower average birth weight of his calves ($P<.01$), less retained placenta at both 24 hrs and 1 week and a higher induction success in cows carrying his progeny than the other sires. Although the decrease in retained placenta and increase in induction success for sire 1 were not significant, this information tends to confirm the conclusion that the genotype of the fetus determines the optimum time for induction as expounded by Carroll (1974).

Adams and Wagner (1970) observed calving difficulty in 10 out of the 46 sucessfully induced cows in their experiment, with repositioning of the fetus being the usual problem. In treatment 2, trial 13, and treatment 2, trial 15, a significant increase ($P<.05$) in calving difficulty was observed over the controls. No other significant differences were found between controls and treated animals when calving difficulty was statistically analyzed. However, a general

trend throughout the 6 trials was a higher calving difficulty score for induced animals above controls. In a composite analysis of trials 11 through 14 least-squares means for calving difficulty score were 0.97, 1.14 and 1.08 for treatment 1 (controls), treatment 2 (induced) and treatment 3 (induced), respectively. The major problem encountered was repositioning of the fetus. In addition, some cows calving during the heat of the day required assistance because of apparent exhaustion. These cows would start calving, work for a short period of time and then quit straining; at that time the calf was pulled with a minimal amount of traction. The stress of calving teamed with heat stress apparently decreased the ability of the cow to expel the calf. This condition was not seen in cows calving at night or on cool days. A similar situation has been observed in Europe where cows under environmental stress at calving show exhaustion during parturition (Jöchle, personal communication). Beardsley et al. (1973) and Bellows (1972) showed an actual increase in difficulty associated with the induction of parturition. On the otherhand, most researchers show no increase in difficult births with induction of parturition (Jöchle, 1971; Carroll, 1974). Wiltbank (1973) reported an increase in the time from start of labor to expulsion of the fetus in induced cows as compared to normal cows. This observation could possibly account for some of the calving difficulty observed in this experiment. Calves were automatically pulled if the second stage of parturition (Roberts, 1956) had not been

completed within 2 hrs, if not a little sooner. This was following recommendations of Wiltbank (1972). Because of the lengthened time taken for parturition in induced cows, extraction could have been employed earlier than was actually necessary.

No differences for any measured parameters were found when 10 mg of flumethasone given in a single injection was compared to 10 mg of flumethasone given in two injections 12 hrs apart in trials 11 and 12. This indicates that splitting the dose of flumethasone over a 12 hr period does not improve the results obtained when parturition is induced with a single 10 mg dose of flumethasone. Furthermore, single injections of a 7.5 mg dose as compared to a 10 mg dose of flumethasone show no significant differences in time from injection to parturition or induction success. However, cows treated with 7.5 mg of flumethasone had significantly less calving difficulty ($P<.01$) than those animals injected with 10 mg of flumethasone. There is no apparent explanation for this fact at thepresent time. Carroll (1974) confirmed the findings of no difference in response between two doses by showing no significant differences in the response between 5 and 10 mg of flumethasone administered in single injections on day 270 of pregnancy. Wagner (1972) showed that 7.5 mg of flumethasone was needed for satisfactory results and that splitting the dose into 2 injections did not improve the response.

Although there was no significant differences found when an A.M. injection of flumethasone was compared to a P.M. injection for various

paremeters, a higher percentage of the cows injected in the P.M. calved during the daylight hours than those injected in the A.M. This is consistent with observations by Bosc (1972) in the ovine where he showed a higher percentage of ewes injected at 20.00 hrs lambing during the daylight hrs than those injected at 08.00 hrs. Bosc (1972b) also indicated that the ewes treated at 20.00 hrs tended to lamb sooner and over a shorter period of time than those treated at 08.00 hrs on the same day. This second observation was not apparent in our data, but more research should be done in this area. The circadian rhythms of birth could be involved with the actual time of birth. Liggins (1972) has hypothesized that the fetus possibly determines the day of birth, while the mother may determine the time. If the above statement is true, then corticosteroid treatment possibly alters the ability of the mother to determine time of birth.

Carroll (1974) reported that survival of induced calves has not been reduced in most cases when treatment took place after day 270 of gestation. Furthermore, calves born earlier than day 270 have less ability to survive. Everitt and Jury (1972) have shown that calf mortality increases as birth weight decreases and Wagner et al. (1974a) has shown a significant correlation of birth weight with day of pregnancy at parturition. The data reported in this paper confirm the above reports. The regression of calf vigor on gestation length at time of injection showed a decrease in vigor as you induce parturition

earlier than approximately day 275 of gestation. However, this regression was quadratic, and also showed a decrease in vigor as induction treatment took place later than day 275. There were only small nonsignificant correlations of vigor with difficulty and birth weight, and the regression of vigor on birth weight was nonsignificant. Hence the decrease in vigor in calves from cows induced later than day 275 of gestation was not caused by an increase in calving difficulty of heavier calves. Possibly the increased time taken for induced cows to expel the fetus (Wiltbank, 1973) is involved with the vigor of the calf.

The percent of retained placenta encountered in induced cows declined as the cows were treated closer to term. Approximately 90 to 100% of the cows treated prior to day 270 were diagnosed as having a retained placenta while 0 to 20% of the cows treated after day 280 of gestation were determined retained. This has been confirmed by Wagner et al. (1971) who showed a high correlation between the percentage of retained placenta and the interval between treatment and due term. Furthermore, Carroll (1974) stated that the lowest frequency of retained placenta is observed near term with higher amounts as you induce earlier in gestation.

The fact that induced cows have a high incidence of retained placenta has caused much concern. However, subsequent fertility and general cow health were not harmed by the presence of retained placental membranes in this study. Cows diagnosed as having a retained placenta

were compared with those without, and no differences in subsequent fertility could be shown. Wagner et al. (1974a) reported good postpartum recovery and subsequent normal fertility in cows with retained placentas after induction. In a comparison between induced cows with a retained placenta and those without, no significant differences were found. All cows with retained placentas in the above studies were treated with broad spectrum antibiotic. Carroll (1974) felt that retained placenta could be predisposing to the development of metritis, and suggested systemic treatment with antibiotics. However, Lauderdale (1972) showed normal postpartum recovery of cows with retained placentas without antibiotic treatment.

The most displeasing fact of the high incidence of retained placenta in induced cows is the objectional site of decaying tissue protruding from the vagina for up to 14 days postcalving. Shedding of a diagnosed retained placenta took place anywhere from 1 to 14 days postcalving, with the greatest percentage being lost from 5 to 12 days after parturition in this study. Jöchle (1973) reported that spontaneous delivery of retained placenta takes place in almost all cases within 8-10 days - mostly around calculated normal termination of the gestation period.

Birth weight was shown to increase as day of gestation at time of flumethasone injection increased. This indicates that the fetus is growing in late gestation. Wagner et al. (1974a) has confirmed this

observation by showing a significant correlation of birth weight with day of pregnancy at parturition. Furthermore, the decreased birth weights found when calves are induced prior to term indicates an increase in fetal weight during late term. However, it is interesting to note that when sire effect was not included in the statistical model the regression of birth weight on gestation length at injection was much greater than when sire effect was included. Sire of calf significantly ($P<.01$) affected birth weight. Hence, the genotype of the calf not only determines its birth weight, but possibly determines when in late gestation growth does take place. Wagner et al. (1974a) found breed differences in growth rate of the fetus in late gestation. They suggested a possible difference in the time of major growth of the fetus depending on the genotype of the fetus.

The data in this study show that as flumethasone is given closer to term, the number of cows responding to the treatment is increased, and the amount of time between flumethasone treatment and parturition is decreased. Work from other investigators have shown a definite increase in the number of cows responding to the induction treatment as treatment occurs closer to term (Adams and Wagner, 1970; Jöchle, 1971). Moreover, Bosc (1971) showed that response to induction varied with the amount injected and day of pregnancy. His work showed a decrease in hours from injection to calving as treatment was given later in gestation.

In addition, the time from treatment to parturition was significantly affected by the sex of the calf. Female calves had a longer period from flumethasone injection to parturition than did male calves. Furthermore, female calves showed a higher incidence of retained placenta after induction than did male calves. The reasons for these observations are not known, and no other researchers have reported these effects. Bosc (1972) looked at the effect of sex of fetus on hours from injection to parturition in the ovine but did not show any significant difference. Moreover, male calves usually have 1 to 2 days longer gestation lengths than females (Hafez, 1968). Increased retained placenta in dams producing femal vaclves vs. males could possibly be explained by the higher cortisol levels found in both the fetal and maternal organisms of cows carrying male calves in late gestation as shown by Lin et al. (1973). If cortisol is the major glucocorticoid in the mechanism of parturition of the bovine as Liggins et al. (1973) hypothesizes it to be in the ovine, and if increased cortisol levels in the fetus dictates the start of parturition in the bovine as Liggins et al. (1973) hypothesizes it does in the ovine, the higher levels of cortisol found in the male fetus could cause the hormonal levels and balances responsible for expulsion of the fetal membranes at spontaneous parturition to be closer to that required for normal placental expulsion in the cow with a male fetus than in one with a female fetus at the same stage of gestation. Obviously this is very speculative idea, and more work is needed before

an accurate explanation can be made.

The induction of parturition with flumethasone had no significant effect on subsequent fertility. Pregnancy rates and fertility scores were not significantly different ($P>.05$) when non-induced controls were compared with successfully induced animals across all trials. This confirmed the work accomplished in the fall of 1972 which showed no adverse effect of the induction procedure on postpartum fertility. Furthermore, LaVoie and Moody (1973a), Carroll (1974) and Wagner et al. (1974a) have shown no deleterious effects of corticosteroid induced parturition on subsequent postpartum fertility. However, it is interesting to note that in trials 13 and 14, fertility score was not significantly correlated with pregnancy rate while in trials 11, 12, 15 and 16, it was. A high correlation between these two parameters would normally be expected because the cows bred earlier in the season would have more of an opportunity to become pregnant. No accurate explanation for this fact has been developed at this time.

In trials 11 through 14 which were made up of cows bred in a 45 day breeding season, the calving season lasted 51 and 35 days, respectively, for control and induced cows. This is a reduction of 16 days in the length of the calving season for the induced animals. A reduction of this size is usually not recommended because of the possible vigor problems involved with induced calves prior to day 270 of gestation (Carroll, 1974). However, no such problems were realized

in this study. This reduction gave the induced cows a longer postpartum recovery period, and allowed labor to be utilized in other sectors of the operation.

In conclusion, the induction of precocious parturition with corticosteroids is a practical tool for the beef producer when used with caution to control the time of calving. One can utilize the induction procedure to confine calving to predetermined times during the entire calving season if accurate breeding information is available, or to terminate the calving season at an early date if the last date of the breeding season is known. These procedures would allow a maximum amount of labor to be available for calving so proper management could be exercised. This would undoubtedly increase cow and calf survival in many situations.

In order to properly utilize the induction of parturition as a management tool one should consider the following recommendations.

1. Adequate calving facilities must be available. This includes calf pulling equipment, various mothering pens, enough area for cows to find seclusion, working area for cow treatment and shelter if adverse weather conditions are expected.

2. Management and labor must be adequate to give proper care to all animals. Experienced personnel with a knowledge of calving and especially the ability to handle problems with parturition are necessary.

3. Proper breeding records are required for all cows if a total induction management system is planned, and the time of the end of the breeding season is necessary if calving season termination is desired.

4. Cows should not be treated any earlier than 12 to 14 days before expected term (7 to 10 days would probably insure better results). Make sure a satisfactory estimation of expected term is available, so some cattle bred to certain bulls with long gestation intervals are not treated too early.

5. Treatment with 7.5 to 10 mg of flumethasone or 20 to 30 mg of dexamethasone in a single injection will give satisfactory results. Date and time of injection depends on when calves are wanted with 46 to 50 hrs being the average time from injection to calving.

6. Cows should be in good condition at calving with no apparent disease problems. Viral conditions must be absent because of the possible reactivation of certain viruses by corticosteroids.

7. Calf disease must be kept under control because of the large number of calves coming in a short period of time. Disinfection of the calving area at frequent intervals is a good way to decrease the chance of disease.

8. Calves should be suckled within 2 to 6 hrs after calving if they have not already suckled prior to this time.

9. All cows with diagnosed retained placenta at 12 to 24 hrs postcalving should be treated with broad spectrum antibiotic prior to 36 hrs postcalving. No attempt at manual removal of the retained placental membranes should be made.

10. Only a few cows should be treated to begin with until a feel for the induction procedure is realized. After that, only the number of cows which you have available facilities and labor to handle should be treated.

11. Induction of parturition has not been shown to reduce calving difficulty, so don't expect it to. If you expect calving difficulty be prepared to have the same amount as you expect if normal parturition was allowed, but remember all calving difficulty normally expected will come within approximately 60 hrs.

The above recommendations for the use of induced parturition in bovine production are a combination of recommendations reported by Carroll

(1974), Wiltbank (1973), Wagner *et al.* (1974a) and experiences received during the collection of the data reported in this thesis.

SUMMARY

The induction of parturition by the use of dexamethasone and flumethasone was studied in 3 field trials in the fall of 1972 and 6 field trials in the fall of 1973, respectively. Eighty-six 2-year-old heifers and 76 aged cows were used in the fall 1972 study, and 30 2-year-old heifers and 275 aged cows were utilized in the fall 1973 study. Cows were part of the Montana State Prison fall calving beef herd and were managed according to usual open range procedures for western range beef production.

The objectives of the fall 1972 study were to determine the effects of a field application of induced parturition on cow and calf performance at calving, subsequent reproductive performance of the cows and subsequent growth performance of the calves. Another objective was to determine if the method of injection of the dexamethasone (intravenously vs. intramuscularly) and/or an increase from one dose to two doses given at a 24 hr interval would result in a reduction in retained placenta and/or an increase in induction success. Parturition was successfully induced in a high percentage of all cows treated. The average time from injection to parturition was approximately 50 hrs. The number of induced cows having diagnosed retained placentas was greater than that of the control cows, and a significant increase in calving difficulty for the induced animals over the controls was realized in one trial. Overall cow health and calf vigor was not affected by the induction treatment. Furthermore, the methods of induction showed no differences as to retained placenta or induction success.

Subsequent cow fertility and calf performance were not affected by the induction treatments.

The fall 1973 study was developed to further evaluate the effects of induced parturition when used in a field situation. An induction schedule was developed to divide the 45 day natural calving period of the aged cows into 4 separate induction trials approximately 10 days apart. Each trial consisted of 3 treatment groups; treatment 1 was the control in each trial and treatments 2 and 3 were cows treated with flumethasone (7.5-10 mg). Treated cows in trials 11-13 were injected between 272-282 days of gestation and in trial 4 between 265-285 days of gestation with 285 days considered normal gestation length. The control cows required 51 days to complete calving compared to 35 days for the flumethasone-treated animals. In an analysis combining all 4 trials, parturition was induced in 89.3 and 90% of the cows in treatments 2 and 3, respectively. Average times from injection of flumethasone to parturition for the cows responding to the treatments were 45.1 and 46.8 hrs for treatments 2 and 3, respectively. The induced animals generally showed significantly earlier birth dates, shorter gestation lengths, increased retained placenta and lower birth weights of their calves than the controls. Calving difficulty was significantly ($P<.01$) increased in treatment 2 over the control in trial 3, but no other differences were found in calving difficulty between the groups. Calf vigor at birth was not affected by the induction treatments. The 30 heifers were randomly assigned to 2 trials

with 2 treatments per trial (1 control and 1 flumethasone treated). All of the heifers responded to the flumethasone treatment with parturition. Retention of the placental membranes was increased in treated animals over controls, and calving difficulty was increased in the treated animals over the controls in trial 15. Subsequent fertility was not adversly affected by the induction treatment. No significant differences were found between flumethasone induced animals and controls for pregnancy rate after the breeding season and fertility score for the first 25 days of breeding.

APPENDIX

APPENDIX TABLE 1. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN TWO-YEAR-OLD HEIFERS AND CALVES AFTER TREATMENT WITH DEXAMETHASONE (TRIAL 1)

		Mean squares					
Source	d.f.	Birth wt. (kg)	Vigor (1.4)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(72 hrs)
Treatment	2	26.881	0.068	1.286*	213.121**	1.754**	2.108**
Error	32	12.470	0.180	0.325	10.591	0.153	0.124

* P<.05
** P<.01

APPENDIX TABLE 2. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN TWO-YEAR-OLD HEIFERS AND CALVES THAT RESPONDED TO TREATMENT WITH DEXAMETHASONE (TRIAL 2)

		Mean squares				
Source	d.f.	Birth wt. (kg)	Vigor (1-4)	Difficulty (1-4)	Retained placenta (24 hrs)	(72 hrs)
Treatment	2	25.700	0.118	0.260	0.360	0.379
Error	42	17.543	0.309	0.411	0.192	0.167

** P<.01

APPENDIX TABLE 3. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH DEXAMETHASONE (TRIAL 3)

		Mean squares				
Source	d.f.	Birth wt. (kg)	Vigor (1-4)	Difficulty (1-4)	Retained placenta (24 hrs)	(72 hrs)
Treatment	2	120.024	0.153	0.057	0.993**	0.473*
Error	73	93.794	0.103	0.053	0.128	0.106

* P .05
** P .01

APPENDIX TABLE 4. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY AND FERTILITY SCORE IN HEIFERS SUCCESSFULLY TREATED WITH FLUMETHASONE (TRIAL 1)

		Mean squares	
Source	d.f.	Pregnant after 45 days breeding season	Fertility score first 25 days of breeding
Treatment	2	0.201	1.044
Sex	2	0.132	0.890
Treatment x sex	3	0.045	0.263
Error	27	0.154	0.680

APPENDIX TABLE 5. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY AND FERTILITY SCORE IN HEIFERS SUCCESSFULLY TREATED WITH FLUMETHASONE (TRIAL 2)

Source	d.f.	Mean squares	
		Pregnant after 45 days breeding season	Fertility score first 25 days of breeding
Treatment	2	0.045	1.518
Sex	2	0.432	1.252
Treatment x sex	4	0.049	0.564
Error	36	0.233	0.645

APPENDIX TABLE 6. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY AND FERTILITY SCORE IN COWS SUCCESSFULLY TREATED WITH FLUMETHASONE (TRIAL 3)

Source	d.f.	Mean squares	
		Pregnant after 45 days breeding season	Fertility score first 25 days of breeding
Treatment	2	0.012	0.428
Sex	2	0.080	1.015
Treatment x sex	4	0.042	1.008
Error	67	0.165	0.879

APPENDIX TABLE 7. LEAST SQUARES ANALYSIS OF VARIANCE FOR SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS SUCCESSFULLY TREATED WITH DEXAMETHASONE (TRIAL 1)

		Mean squares			
Source	d.f.	Actual weaning wt.	d.f.	Adj. 205-day wt.[a]	ADG (birth to weaning)[a]
Treatment	2	69.711	2	103.290	0.003
Sex	1	146.832	--	--	--
Treatment x sex	2	957.445	--	--	--
Error	26	464.598	29	383.440	0.008

[a] Sex and treatments x sex effects were deleted from the least squares model for adjusted 205-day wt. and ADG analysis.

APPENDIX TABLE 8. LEAST SQUARES ANALYSIS OF VARIANCE FOR SUBSEQUENT PERFORMANCE OF CALVES FROM HEIFERS SUCCESSFULLY TREATED WITH DEXAMETHASONE (TRIAL 2)

		Mean squares			
Source	d.f.	Actual weaning wt.	d.f.	Adj. 205-day wt.[a]	ADG (birth to weaning)[a]
Treatment	2	403.446	2	350.654	0.008
Sex	1	524.040	--	--	--
Treatment x sex	2	775.339	--	--	--
Error	30	349.544	33	368.161	0.008

[a] Sex and treatments x sex effects were deleted from the least squares model for adjusted 205-day wt. and ADG analysis.

APPENDIX TABLE 9. LEAST SQUARES ANALYSIS OF VARIANCE FOR SUBSEQUENT PERFORMANCE OF CALVES FROM COWS SUCCESSFULLY TREATED WITH DEXAMETHASONE (TRIAL 3)

		Mean squares			
Source	d.f.	Actual weaning wt.	d.f.	Adj. 205-day wt.[a]	ADG (birth to weaning)[a]
Treatment	2	859.232	2	178.442	0.008
Sex	1	3.538	--	--	--
Treatment x sex	2	362.226	--	--	--
Error	57	445.444	59	441.627	0.009

[a] Sex and treatments x sex effects were deleted from the least squares model for adjusted 205-day wt. and ADG analysis.

APPENDIX TABLE 10. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 11)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(1 week)
Treatment	3	220.659**	60.798*	0.019	0.858	193.885**	1.558**	0.536*
Sire	3	79.715**	106.368**	0.034	0.645	54.219**	0.041	0.200
Sex	1	0.311	174.450**	0.404	0.404	2.633	0.394	0.030
Previous treatment	2	13.117	7.568	0.048	0.285	2.895	0.081	0.041
Error	60	9.689	19.498	0.077	0.604	9.493	0.135	0.131

* $P < .05$
** $P < .01$

APPENDIX TABLE 11. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 11)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(1 week)
Treatment	2	306.961**	74.396*	0.027	1.189	287.630**	2.305**	0.747**
Sire	3	79.560**	98.853**	0.034	0.647	53.524**	0.048	0.196
Sex	1	0.264	145.373**	0.044	0.413	2.833	0.258	0.003
Previous treatment	2	13.090	6.726	0.048	0.288	2.905	0.071	0.043
Error	59	9.853	19.377	0.078	0.614	9.650	0.131	0.126

*P<.05
**P<.01

APPENDIX TABLE 12. LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INJECTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 11)

Source	d.f.	Mean squares Hours from injection to parturition
Treatment	1	6564.234
Sire	3	9730.113
Sex	1	62712.690
Previous treatment	2	4541.533
Error	24	14936.960

APPENDIX TABLE 13. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS AFTER TREATMENT WITH FLUMETHASONE (TRIAL 11)

Source	d.f.	Mean squares Induction success
Treatment	1	0.010
Sire	4	0.105
Sex	1	0.003
Regression of gestation length at time of injection	1	0.369*
Error	27	0.052

* $P < .05$

APPENDIX TABLE 14. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 12)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(1 week)
Treatment	3	305.455**	329.459**	0.000	0.432	272.715**	2.261**	1.426**
Sire	3	87.965**	159.307**	0.000	0.591	101.118**	0.181	0.165
Sex	1	1.313	9.409	0.000	0.005	1.689	0.224	0.001
Previous treatment	2	23.115	45.928*	0.000	1.401	28.718	0.112	0.180
Error	65	19.508	13.800	0.000	1.872	18.721	0.113	0.133

*P<.05
**P<.01

APPENDIX TABLE 15. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 12)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(1 week)
Treatment	2	343.824**	441.782**	0.000	0.512	394.291**	3.163**	2.056**
Sire	3	103.565**	123.626**	0.000	0.652	90.008**	0.187	0.166
Sex	1	1.857	7.996	0.000	0.054	0.539	0.218	0.002
Previous treatment	2	19.173	43.138*	0.000	1.783	17.834	0.108	0.177
Error	63	18.417	12.769	0.000	1.804	18.037	0.117	0.137

*P<.05
**P<.01

APPENDIX TABLE 16. LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INJECTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 12)

Source	d.f.	Mean squares Hours from injection to parturition
Treatment	1	55534.26
Sire	3	73004.90
Sex	1	129.54
Previous treatment	2	6088.89
Error	30	27556.35

APPENDIX TABLE 17. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRAIL 12)

Source	d.f.	Mean squares Induction success
Treatment	1	0.086
Sex	1	0.048
Regression of gestation length at time of injection	1	0.650**
Error	37	0.046

**P < .01

APPENDIX TABLE 18. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 13)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(1 week)
Treatment	3	53.612	208.243*	0.169	3.146*	49.348**	0.885**	0.394
Sire	4	9.851	200.046*	0.087	1.070	35.553**	0.099	0.036
Sex	1	3.313	144.227	0.266	9.644**	0.138	0.001	0.0003
Previous treatment	2	0.391	25.450	0.010	0.270	0.887	0.166	0.127
Error	23	20.519	58.626	0.123	0.964	7.994	0.170	0.182

*P<.05
**P<.01

APPENDIX TABLE 19. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 13)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	Retained placenta (1 week)
Treatment	2	3.266	57.240*	0.257	5.157*	43.590*	1.171**	0.492
Sire	4	9.559	38.996*	0.112	1.468	36.476*	0.102	0.037
Sex	1	4.225	29.233	0.367	11.780**	1.154	0.001	0.0001
Previous treatment	2	0.046	11.415	0.006	0.042	1.012	0.209	0.157
Error	21	22.314	12.013	0.128	0.933	8.473	0.181	0.196

*P<.05
**P<.01

APPENDIX TABLE 20. LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INJECTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 13)

Source	d.f.	Mean squares Hours from injection to parturition
Treatment	1	17399.950
Sire	4	9316.570
Sex	1	89008.730*
Previous treatment	2	561.970
Error	12	15240.320

*P<.05

APPENDIX TABLE 21. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS AFTER TREATMENT WITH FLUMETHASONE (TRIAL 13)

Source	d.f.	Mean squares Induction success
Treatment	1	0.261
Sire	4	0.024
Sex	1	0.105
Regression of gestation length at time of injection	1	0.272
Error	16	0.119

APPENDIX TABLE 22. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 14)

		Mean squares					
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Retained placenta (24 hrs)	(1 week)
Treatment	3	429.013**	198.274**	0.008	2.372	1.800**	1.067**
Sire	1	1.667	516.773**	0.0001	1.277	0.977**	0.568
Sex	1	22.940	4.308	0.018	1.483	0.092	0.153
Previous treatment	2	19.580	34.406	0.001	1.361	0.173	0.047
Error	88	10.375	19.618	0.011	2.478	0.172	0.164

*P<.05
**P<.01

APPENDIX TABLE 23. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 14)

		Mean squares					
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Retained placenta (24 hrs)	(1 week)
Treatment	2	629.417**	221.611**	0.010	3.028	2.452**	1.298**
Sire	1	1.672	525.932**	0.0001	1.406	0.950*	0.568
Sex	1	26.119	0.102	0.020	1.494	0.024	0.181
Previous treatment	2	21.577	18.219	0.001	2.845	0.231	0.056
Error	79	11.476	16.563	0.012	2.526	0.180	0.182

*P<.05
**P<.01

APPENDIX TABLE 24. LEAST SQUARES ANALYSIS OF VARIANCE FOR HOURS FROM INDUCTION TO PARTURITION IN COWS THAT RESPONDED TO TREATMENT WITH FLUMETHASONE (TRIAL 14)

Source	d.f.	Mean squares Hours from injection to parturition
Treatment	1	113.953
Sire	1	94370.190
Sex	1	6518.998
Previous treatment	2	6556.480
Error	59	25075.060

APPENDIX TABLE 25. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN COWS AFTER TREATMENT WITH FLUMETHASONE (TRIAL 14)

Source	d.f.	Mean squares Induction success
Treatment	1	0.059
Sire	1	0.064
Sex	1	0.403
Previous treatment	2	0.027
Error	69	0.116

APPENDIX TABLE 26. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN HEIFERS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 15)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(1 week)
Treatment	1	121.464	13.728	0.019	7.890*	101.157**	2.689**	2.689**
Sex	1	31.621	6.533	0.019	0.047	8.713	0.075	0.075
Treatment x sex	1	33.177	0.197	0.019	0.047	0.242	0.075	0.075
Error	14	56.983	6.866	0.061	1.582	9.016	0.102	0.102

*P<.05
**P<.01

APPENDIX TABLE 27. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN HEIFERS AND CALVES AFTER TREATMENT WITH FLUMETHASONE (TRIAL 16)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Gestation length	Retained placenta (24 hrs)	(1 week)
Treatment	1	326.294*	49.915**	0.000	1.226	60.397	0.123	0.240
Sex	1	16.490	13.162	0.000	1.226	0.240	0.005	0.005
Treatment x sex	1	21.353	22.788*	0.000	5.931	0.397	0.593	0.005
Error	8	45.479	3.951	0.000	4.271	11.760	0.240	0.177

*P<.05
**P<.01

APPENDIX TABLE 28. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES RESPONDING TO TREATMENT WITH FLUMETHASONE (TRIAL 11-14)

Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Vigor (1-3)	Difficulty (1-4)	Retained placenta (24 hrs)	(1 week)
Treatment	2	649.423**	606.799**	0.043	4.747*	7.996**	4.288**
Trial	3	3205.013**	165.413**	0.212**	0.158	0.330	0.289
Sex	1	4.781	117.090**	0.168*	0.188	0.325	0.007
Sire	4	119.512**	339.322**	0.154**	0.507	0.308	0.285
Previous treatment	2	14.237	26.175	0.023	0.342	0.181	0.129
Treatment x trial	6	89.152**	29.749	0.050	0.874	0.189	0.106
Error	239	13.941	16.177	0.040	1.459	0.147	0.153

*P<.05
**P<.01

APPENDIX TABLE 29. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED TO THE TREATMENT OF FLUMETHASONE IN TRIALS 11 AND 12 (CONTROLS EXCLUDED)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Calf vigor (1-3)	Difficulty (1-4)	Retained placenta (24 hrs)	(1 week)	Hours from injection to calving
Trial	1	1481.675**	154.822**	0.009	0.072	0.003	0.373	10820.850
Treatment	1	0.067	5.223	0.008	0.359	0.053	0.050	938.365
Sex	1	0.294	11.482	0.015	0.216	0.950*	0.029	32168.600
Sire	3	0.538	90.551**	0.007	0.759	0.431	0.523	60811.890*
Treatment x trial	1	1.978*	31.571	0.010	0.224	0.179	0.291	67679.360
Treatment x sire	3	0.823	2.455	0.011	0.205	0.126	0.276	11962.160
Regression on gestation length at time of injection[a]	1	3.080**	22.424	0.358**	0.222	1.316*	1.060*	51552.970
Error	58	0.359	14.760	0.015	1.786	0.205	0.233	20752.190

*P<.05
**P<.01
[a] All regression means squares are linear except for that of vigor which is quadractic. This quadratic value was analyzed in a model excluding bulls with one more observation.

APPENDIX TABLE 30. LEAST SQUARES ANALYSIS OF VARIANCE FOR INDUCTION SUCCESS IN FLUMETHASONE TREATED COWS (CONTROLS EXCLUDED)

Source	d.f.	Mean squares Induction success Trials 11-12	d.f.	Mean squares Induction success Trials 11-14
Trial	1	0.000	3	0.021
Treatment	1	0.033	1	0.055
Sex	1	0.055	1	0.106
Sire	3	0.011	4	0.026
Treatment x trial	1	0.002	3	0.129
Treatment x sire	3	0.056	4	0.064
Linear regression on gestation length at time of injection	1	0.346**	1	0.439*
Error	62	0.049	115	0.094

*P<.05
**P<.01

APPENDIX TABLE 31. LEAST SQUARES ANALYSIS OF VARIANCE FOR VARIOUS TRAITS IN COWS AND CALVES THAT RESPONDED SUCCESSFULLY TO TREATMENT WITH FLUMETHASONE IN TRIALS 11-14 (CONTROLS EXCLUDED)

		Mean squares						
Source	d.f.	Birth date (day of year)	Birth wt. (kg)	Calf vigor (1-3)	Difficulty (1-4)	Retained placenta (24 hrs)		Hours from injection to calving
Trial	3	1673.320**	96.520**	0.146*	0.441	0.016	0.128	11210.490
Treatment	1	0.266	0.946	0.001	0.654	0.090	0.063	17.268
Sex	1	1.220	36.904	0.081	1.559	0.124*	0.318	110152.330*
Sire	4	0.813	108.061**	0.097	0.313	0.333	0.284	51268.960
Treatment x trial	3	0.631	30.219	0.110	1.369	0.138	0.070	20286.230
Treatment x sire	4	0.458	7.982	0.036	0.535	0.093	0.064	13218.720
Regression on gestation length at time of injection[a]	1	2.926*	93.376*	0.581**	0.192	1.616**	0.816	118125.800*
Error	100	0.431	14.215	0.044	1.475	0.212	0.248	23102.640

*P<.05
**P<.01
[a] All regression mean squares are linear except for that of vigor which is quadratic.

APPENDIX TABLE 32. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRIAL 11)

Source	d.f.	Mean squares: Pregnant after 45 days breeding season	Mean squares: Fertility score first 25 days of breeding
Treatment	3	0.056	0.420
Previous treatment	2	0.086	0.124
Error	64	0.129	0.733

APPENDIX TABLE 33. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRIAL 12)

Source	d.f.	Mean squares: Pregnant after 45 days breeding season	Mean squares: Fertility score first 25 days of breeding
Treatment	3	0.100	1.203
Previous treatment	2	0.147	0.609
Error	62	0.125	0.702

APPENDIX TABLE 34. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRIAL 13)

Source	d.f.	Mean squares: Pregnant after 45 days breeding season	Mean squares: Fertility score first 25 days of breeding
Treatment	3	0.242	0.918
Previous treatment	2	0.088	0.151
Error	26	0.262	0.535

APPENDIX TABLE 35. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN COWS TREATED WITH FLUMETHASONE (TRAIL 14)

Source	d.f.	Mean squares: Pregnant after 45 days breeding season	Mean squares: Fertility score first 25 days of breeding
Treatment	3	0.179	0.773
Previous treatment	2	0.007	0.189
Error	82	0.161	0.686

APPENDIX TABLE 36. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN HEIFERS TREATED WITH FLUMETHASONE (TRIAL 15)

		Mean squares	
Source	d.f.	Pregnant after 45 days breeding season	Fertility score first 25 days of breeding
Treatment	1	0.000	0.017
Error	16	0.111	0.882

APPENDIX TABLE 37. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN HEIFERS TREATED WITH FLUMETHASONE (TRIAL 16)

		Mean squares	
Source	d.f.	Pregnant after 45 days breeding season	Fertility score first 25 days of breeding
Treatment	1	0.010	2.002
Error	10	0.166	0.891

APPENDIX TABLE 38. LEAST SQUARES ANALYSIS OF VARIANCE FOR PREGNANCY RATE AND FERTILITY SCORE IN ALL COWS RESPONDING TO TREATMENT WITH FLUMETHASONE (TRIALS 11-14)

		Mean squares	
Source	d.f.	Pregnant after 45 days breeding season	Fertility score first 25 days of breeding
Treatment	2	0.090	0.951
Previous treatment	2	0.178	0.334
Trial	3	0.675**	0.150
Treatment x trial	6	0.084	0.993
Error	226	0.151	0.649

**P<.01

APPENDIX TABLE 39. LEAST SQUARES ANALYSIS OF VARIANCE FOR GESTATION LENGTH AT TIME OF PARTURITION AND RETENTION OF PLACENTAL MEMBRANES AT 24 HOURS AND ONE WEEK AFTER PARTURITION IN COWS SUCCESSFULLY TREATED WITH FLUMETHASONE

		Mean squares				
		Trials 11-12			Trials 11-14	
Source	d.f.	Pregnant after 45 day breeding season	Fertility score first 25 days of breeding	d.f.	Pregnant after 45 day breeding season	Fertility score first 25 days of breeding
Trial	1	0.009	0.149	3	0.685**	0.083
Treatment	2	0.168	2.214*	2	0.123	0.652
Previous treatment	2	0.175	0.766	2	0.150	0.307
Retained placenta (24 hrs)	1	0.059	0.399	1	0.128	0.456
Retained placenta (1 week)	1	0.014	0.428	1	0.000	1.261
Trial x treatment	2	0.013	0.458	6	0.098	1.033
Linear regression on gestation length at time of parturition[a]	1	0.426	0.966	1	--	--
Error	122	0.128	0.691	223	0.152	0.648

* P<.05
**P<.01
[a] Of no value in trials 11 through 14 because of lack of gestation lengths.

LITERATURE CITED

Adams, W. M. 1969. The elective induction of labour and parturition in cattle. J. Amer. Vet. Med. Ass. 154:261.

Adams, W. M. and W. C. Wagner. 1970. The role of corticoids in parturition. Biol. Reprod. 3:223.

Alexander, D. P., H. G. Britton, V. H. T. James, D. A. Nixon, R. A. Parker, E. M. Wintour and R. D. Wright. 1968. Steroid secretion by the adrenal gland of foetal and neonatal sheep. J. Endocr. 40:1.

Alexander, D. P., H. G. Britton, M. L. Forsling, D. A. Nixon and J. G. Ratcliffe. 1971. The concentrations of adrenocorticotrophin, vasopressin and oxytocin in the foetal and maternal plasma of the sheep in the latter half of gestation. J. Endocr. 49:179.

Alm, C. C., J. Sullivan and N. L. First. 1972. Dexamethasone induced parturition in the mare. J. Anim. Sci. 35:1115.

Bailey, L. F., M. W. Mclennan, D. M. McLean, P. R. Hartford and G. L. Munro. 1973. The use of dexamethasone trimethylacetate to advance parturition in dairy cows. Austr. Vet. J. 49:567.

Bassett, J. M. and G. D. Thorburn. 1969. Foetal plasma corticosteroids and the initiation of parturition in the sheep. J. Endocr. 44:285.

Bassett, J. M., G. D. Thorburn and D. N Nicol. 1973. Regulation of insulin secretion in the ovine foetus in utero. Effects of sodium volerate on secretion and of adrenocorticotrophin-induced premature parturition on the insulin secretory response to glucose. J. Endocr. 56:13.

Bassett, J. M., T. J. Oxborrow, I. D. Smith and G. D. Thorburn. 1969. The concentration of progesterone in the peripheral plasma of the pregnant ewe. J. Endocr. 45:449.

Beardsley, G. L., L. D. Muller and M. S. Owens. 1973. Initiation of parturition in dairy cows with dexamethasone. I. Cow response and performance. J. Dairy Sci. 56:640.

Beardsley, G. L., L. D. Muller, R. P. Ellis, D. E. Reed and M. J. Owens. 1973. Initiation of parturition in dairy cows with dexamethasone. II. Calf performance. J. Dairy Sci. 56:640.

Bedford, C. A., J. R. G. Challis, F. A. Harrison and R. B. Heap. 1972. The role of oestrogens and progesterone in the onset of parturition in various species. J. Reprod. Fert. Suppl. 16:1.

Bellows, R. A. 1972. Factors affecting losses at calving. Proc. of Short Course for Veterinarians "Beef Cattle Reproduction". Colo. State Univ. p. 11.

Bellows, R. A., R. E. Short, D. C. Anderson, B. W. Knapp and O. F. Pahnish. 1971. Cause and effect relationships associated with calving difficulty and calf birth weight. J. Anim. Sci. 33:407.

Binns, W., W. A. Anderson and D. J. Sullivan. 1960. Cyclopian-type malformation in lambs. J. Amer. Vet. Med. Ass. 137:515.

Bosc, M. S. 1971. Etude de l'induction de la parturition, chez la vache parun corticosteroide de synthese. Ann. Biol. Anim. Bioch. Biophys. 11:581. IN. E. J. Carroll. 1974. Induction of parturition in farm animals. J. Anim. Sci. 38:1 (Suppl. I).

Bosc, M. J. 1972a. Consequences ur la parturition, de l'hyphphysectomie de la mere ou du foetus, chez la brebis traitee par la dexamethasone. C. R. Acad. Sci. 274:93.

Bosc, M. J. 1972b. The induction of synchronization of lambing with the aid of dexamethasone. J. Reprod. Fert. 28:347.

Carroll, E. J. 1974. Induction of parturition in farm animals. J. Anim. Sci. 38:1 (Suppl. I).

Carter, E. I., D. G. Butler and V. E. O. Valli. 1971. Dexamethasone for therapuetic abortion of a cow with hydrops allantois. Mod. Vet. Prac. 52:43.

Catchpole, H. R. 1969. Harmonal mechanisms during preganancy and parturition. IN. H H. Cole and P. T. Cupps (Ed.) Reproduction in Domestic Animals. Vol. I. Academic Press, N. Y.

Challis, J. R. G. 1971. Sharp increase in free circulating oestrogens immediately before parturition in sheep. Nature, London 229:208.

Chamley, W. A., J. M. Buckmaster, M. E. Cerini, I. A. Cumming, J. R. Goding, J. M. Obst, A. Williams and C. Winfield. 1973. Changes in the levels of progesterone, corticosteroids, estrone, estradiol-17β, lutenizing hormone, and prolactin in the peripheral plasma of the ewe during late pregnancy and at parturition. Biology of Reprod. 9:30.

Chard, T. 1972. The posterior pituitary in human and animal parturition. J. Reprod. Fert. Suppl. 16:121.

Clegg, M. T. 1959. Factors affecting gestation length and parturition. In. H. H. Cole and P. T. Cupps (Ed.) Reproduction in Farm Animals. Vol. I. Academic Press, N. Y.

Coggins, E. G. and N. L. First. 1973. Effects of DXMS on gestation length in sows with spontaneous and induced Cl. J. Anim. Sci. 37:306.

Comline, R. S., P. W. Nathanielsz, R. B. Paisey and M. Silver. 1970. Effect of foetal hypophysectomy on catecholamine levels in the lamb adrenal during prolonged gestation. Nature, London. 225-739.

Comline, R. S. and M. Silver. 1961. The release of adrenalin and nor-adrenalin from the adrenal glands of the foetal sheep. J. Physiol. 156:424.

Davis, S. L., L. E. Reichert and G. D. Niswender. 1971. Serum levels of prolactin in sheep as measured by radioimmunoassay. Biol. Reprod. 4:145.

DeFries, J. C., R. W. Touchberry and R. L. Hays. 1959. Heritability of the length of the gestation period in dairy cattle. J. Dairy Sci. 42:598.

Drost, M. and L. W. Holm. 1968. Prolonged gestation in ewes after foetal adrenalectomy. J. Endocr. 40:293.

Emadi, M. and D. E. Noakes. 1973. The pharmacological control of the time of parturition in the ewe. Vet. Rec. 93:76.

Evans, L. E., W. C. Wagner and W. M. Adams. 1971. Plasma progesterone at induced parturition. J. Anim. Sci. 33:1157.

Everitt, G. C. and K. E. Jury. 1972. Beef production from the dairy herd: calving performance of cows. N.Z. J. Agri. Res. 15:228.

Fell, L. R., C. Beck, J. M. Brown, K. J. Catt, I. A. Cumming and J. R. Goding. 1972. Solid-phase radioimmunoassay of ovine prolactin in antibody coated tubes. Prolactin secretion during estradiol treatment, at parturition and milking. Endocr. 91:1329.

Findlay, J. K. and R. I. Cox. 1970. Oestrogens in the plasma of the sheep foetus. J. Endocr. 46:281.

Findlay, J. K. and R. F. Seamark. 1971. The biosynthesis of oestrogens in the ovine foeto-placental unit. J. Reprod. Fert. 24:141.

First, N. L. and R. B. Staigmiller. 1973. Effects of ovariectomy, dexamethasone and progesterone on the main tenance of pregnancy in swine. J. Anim. Sci. 37:1191.

Fuchs, F. 1971. Endocrinology of Labor. In. F. Fuchs and A. Klopper (Ed.) Endocrinology of Pregnancy. Harper and Row, N. Y.

Fylling, P. 1969. Serial progesterone assays in peripheral blood of sheep during the last week of pregnancy. Acta Endocr. Suppl. 138:251.

Fylling, P. 1970. The effect of pregnancy, ovariectomy and parturition on plasma progesterone level in sheep. Acta Endocr. 65:273.

Fylling, P. 1971. Premature parturition following dexamethasone administration to pregnant ewes. Acta Endocr. 66:289.

Gomes, W. R. and R. E. Erb. 1965. Progesterone in bovine reproduction: a review. J. Dairy Sci. 48:314.

Hafez, E. S. E. 1968. Gestation, Prenatal Development and Parturition. In. E.S.E. Hafez (Ed.) Reproduction in Farm Animals. Lea and Febiger, Philadelphia.

Harvey, W. R. 1960. Least-squares analysis of data with unequal subclass numbers. ARS 20:8.

Hendricks, D. M., J. F. Dickey, J. R. Hill and W. E. Johnston. 1972. Plasma estrogen and progesterone levels after mating, and during late pregnancy and postpartum in cows. Endocr. 90:1336.

Holm, L. W. and S. J. Galligan. 1966. Estrogens in the peripheral plasma of cows during normal and prolonged gestation. Am. J. Obstet. Gynecol. 95:887.

Holm, L. W. H. R. Parker and S. J. Galligan. 1961. Adrenal insufficiency in postmature Holstein calves. Am. J. Obstet. Gynecol. 81:1000.

Huston, K. and H. T. Gier. 1958. An anatomical description of a hydrocephalic calf from prolonged gestation and the possible relationships of these conditions. Cornell Vet. 48:45.

Ingalls, W. G., E. M. Convey and H. D. Hafs. 1973. Bovine serum LH, GH, and prolactin during late pregnancy, parturition and early lactation. Proc. Society for Experimental Biology and Medicine 143:161.

Jafar, S. M., A. B. Chapman and L. E. Casida. 1950. Causes of variation in length of gestation in dairy cattle. J. Anim. Sci. 9:593.

Jöchle, W. 1971. Corticoid induced parturition in domestic animals: mechanisms of action and economic importance. Folia Vet. Lactina. Roma 1:229.

Jöchle, W. 1973. Corticoid-induced parturition in domestic animals. Ann. Review Pharmacol. 13:33.

Jöchle, W., H. Esparza, T. Gimenez and M. A. Hidalgo. 1972. Inhibition of corticoid-induced parturition by progesterone in cattle: effect on delivery and calf viability. 28:407.

Karg, H., S. Bohm, O. Bunzler and S. Muller. 1971. Erfahrungen uber die geburtseinleitung beim rind mit glukokortikoiden. Dtsch. Tievarzti. Wschv. 78:25 In. E. J. Carroll. 1974. Induction of Parturition in Farm Animals. J. Anim. Sci. 38:1 (Suppl. I)

Kendall, J. Z. and G. C. Liggins. 1971. The effect of corticosteroids on pregnancy in the rabbit. 4th Asia and Oceanic Congr. Endocr. Auckland, N.Z. In. W. Jöchle 1971. Corticoid induced parturition in domestic animals:mechansm of action and economic importance. Folia Vet. Latina. Roma 1:229.

Kenneth, J. R. 1953. Tech. Commus. Imp. Animal Breed. Genet. No. 5. In. H. H. Cole and P. T. Cupps (Ed.) Reproduction in Farm Animals. Vol. I. Academic Press, N.Y.

Kirsch, R. E. 1938. A study on the control of length of gestation in the rat, with notes on maintenance and termination of gestation. Amer. J. Physiol. 122:86.

Lamond, D. R., R. V. Tomlinson, M. Drost, D. M. Hendricks and W. Jöchle. 1973. Studies of prostaglandin $F_2\alpha$ in the cow. Prostaglanlins 4:269:

Lanman, J. T. 1968. Delays during reproduction and their effects on the embryo and fetus. New England J. Med. 278:993, 1047, 1092.

Lanman, J. T. and A. Schaffer. 1968. Gestational effects of fetal decapitation in sheep. Fertil. Steril. 19:598.

Lauderdale, J. W. 1972. Effect of corticoid administration on bovine pregnancy. J. Am. Vet. Med. Ass. 160:867.

LaVoie, V. A. and E. L. Moody. 1973a. Estrogen pre-treatment of corticoid induced parturition in cattle. J. Anim. Sci. 37:770.

LaVoie, V. A. and E. L. Moody. 1973b. Cow and calf performance after dexamethasone induced calving. Proc. West. Sec. Amer. Soc. Anim. Sci. 24:285.

Liggins, G. C. 1968. Premature parturition after infusion of corticotrophin or cortisol into foetal lambs. J. Endocr. 42:323.

Liggins, G. C. 1969. Premature delivery of foetal lambs infused with glucocorticoids. J. Endocr. 45:515.

Liggins, G. C. 1972. The Fetus and Birth. In. C. R. Austin and R. V. Short (Ed.). Reproduction in Mammals. Vol. II. Cambridge University Press.

Liggins, G. C. 1973. The physiological role of prostaglandins in parturition. J. Reprod. Fert. Suppl. 18:143.

Liggins, G. C., R. S. Fairclough, S. A. Grieves, J. Z. Kendall and B. S. Knox. 1973. The mechanism of initiation of parturition in the ewe. Recent Progress in Hormone Research. Vol. 29:111. Academic Press, New York and London.

Liggins, G. C. and S. A. Grieves. 1971. Possible role for prostaglandin $F_2\alpha$ in parturition in sheep. Nature, London 232:629.

Liggins, G. C., S. A. Grieves, J. Z. Kendall and B. S. Knox. 1972. The physiological roles of progesterone, oestradiol 17β and prostaglandin $F_2\alpha$ in the control of ovine parturition. J. Reprod. Fert. Suppl. 16:85.

Liggins, G. C. and P. C. Kennedy. 1968. Effects of electrocoagulation of the foetal lamb hypophysis on growth and development. J. Endocr. 40:371.

Liggins, G. C., P. C. Kennedy and L. W. Holm. 1967. Failure of initiation of parturition after electrocoagulation of the pituitary of the foetal lamb. Amer. J. Obstet. Gynecol. 98:1080.

Lin, Y. C., W. D. Oxender and H. D. Hafs. 1973. Fetal and maternal cortisol in the bovine. J. Anim. Sci. 37:319.

Linzell, J. L. and R. B. Hep. 1968. A comparison of progesterone metabolism in the pregnant sheep and goat: sources of production and an estimation of uptake by some target organs. J. Endocr. 41:433.

Lucas, J. M. S. and A. Notman. 1974. The use of corticosteroids to synchronize parturition in sheep. Br. Vet. J. 130:i.

Meites, J., H. D. Webster, F. W. Young, F. Thorp, Jr. and R. H. Hatch. 1951. Effects of corpora lutea removal and replacement with progesterone on pregnancy in goats. J. Anim. Sci. 10:411.

Morrow, D. A., S. S. Roberts, K. McEntee and H. G. Gray. 1966. Postpartum ovarian activity and uterine involution in dairy cattle. J. Am. Vet. Med. Ass. 149:1596.

Nathanielsz, P. W., R. S.Comaline, M. Silver and R. B. Paisey. 1972. Cortisol metabolism in the fetal and neonatal sheep. J. Reprod. Fert. Suppl. 16:39.

North, S. A., E. R. Hauser and N. L. First. 1973. Induction of parturition in swine and rabbits with the corticosteroid dexamethasone. J. Anim. Sci. 36:1170.

Obst, J. M. and R. F. Seamark. 1972a. Plasma oestrogen concentrations in ewes during parturition. J. Reprod. Fert. 28:161.

Obst, J. M. and R. F. Seamark. 1972b. Plasma hormone levels during pregnancy and parturition in ewes grazing Yarloop clover pastures. J. Reprod. Fert. 29:146.

O'Farrell, K. S. and J. P. Crowly. 1973. Some observations on the use of dexamethasone T.M.A. for the induction of premature calving. Vet. Rec. 93:75.

O'Mary, C. C. and D. J. Coonrad. 1973. Shortening gestation in early bred beef heifers. J. Anim. Sci. 37:249.

Osinga, A. 1970. Oestrogen excretion by the pregnant bovine and its relation with some characters of gestation and parturition. Thesis. State Agricultural University, Wageningen, Netherlands.

Osinga, A., Th. Stegenga and W. Jochle. 1971. Initiation of parturition in dairy cows with a synthetic corticosteroid. Zuchthyg. 6:64.

Pharriss, B. B., S. A. Tillson and R. R. Erickson. 1972. Prostaglandins in luteal function. Recent Progress in Hormone Research 28:51.

Roberts, S. J. 1956. Veterinary Obstetrics and Genital Disease. Published by the author. Ithaca, New York.

Roberston, H. A. 1974. Changes in the concentration of unconjugated oestrone, oestradiol-17α and oestradiol-17β in the maternal plasma of the pregnant cow in relation to the initiation of parturition and lactation. J. Reprod. Fert. 36:1.

Robertson, H. A. and T. C. Smeaton. 1973. The concentration of unconjugated oestrone, oestradiol-17α and oestradiol-17β in the maternal plasma of the pregnant ewe in relation to the initiation of parturition and lactation. 1973. J. Reprod. Fert. 35:461.

Schalms, D., B. Hoffman, S. Fisher, E. Marz and H. Karg. 1972. Simultaneous determination of L.H. and progesterone in peripheral bovine blood during pregnancy, normal and corticoid-induced parturition and the postpartum period. J. Reprod. Fert. 29:37.

Schofield, B. M. 1968. Parturition. In. Anne McLaren (Ed.) Advances in Reproductive Physiology. 3:9. Academic Press, N. Y.

Sheffy, B. E. and D. H. Davies. 1972. Reactivation of a bovine herpesvirus after corticosteroid treatment. Proc. Soc. Exp. Biol. Med. 140:974.

Short, R. V. 1958. Progesterone in blood. II. Progesterone in the peripheral blood of pregnant cows. J. Endocr. 16:426.

Short, R. V. 1960. Blood progesterone levels in relation to parturition. J. Reprod. Fert. 1:61.

Short, R. V. and J. G. Rowell. 1962. The half-life of progesterone in the peripheral blood of a ewe at two states of gestation. J. Endocr. 25:369.

Skinner, J. D., W. Jöchle and J. W. Nel. 1970. Induction of parturition in Karakul and crossbred ewes with flumethasone. Agroanimalio 2:99.

Smith, V. G., L. H. Edgerton, H. D. Hafs and E. M. Convey. 1973. Bovine serum estrogens, progestins and glucocorticoids during late pregnancy, parturition and early lactation. J. Anim. Sci. 36:391.

Snedecor, G. W. and W. G. Cockran. 1967. Statistical Methods (6th Ed.). Iowa State Univ. Press, Ames, Iowa.

Stabenfeldt, G. H., B. I. Osborn and L. L. Ewing. 1970. Peripheral plasma progesterone levels in the cow during pregnancy and parturition. Am. J. Physiol. 218:571.

Thorburn, G. D. and P. E. Mattner. 1971. Anastomosis of the uteroovarian and anterior mammary vein for collection of the uteroovarian venous blood; progesterone secretion rates in cyclic ewes. J. Endocr. 50:307.

Thorburn, G. D., D. H. Nicol, J. M. Bassett, D. A. Shutt and R. I. Cox. 1972. Parturition in the goat and sheep: Changes in corticosteroids, progesterone, oestrogens and prostaglandin F. J. Reprod. Fert., Suppl. 16:61.

Van Kampen, K. R. and L. C. Ellis. 1972. Prolonged gestation in ewes ingesting veratrum Californieum: Morphological changes and steroid biosynthesis in the endocrine organs of cyclopic lambs. J. Endocr. 62:549.

Van Rensburg, S. J. 1967. Gestation in sheep after foetal adrenalectomy and cortisol acetate administration. J. Endocr. 38:83.

Van Rensburg, S. J. 1970. The termination of pregnancy. Proc. S. Afr. Soc. Anim. Prod. 9:17.

Van Wagenen, G. and W. H. Newton. 1949. Maintenance of the habitus of pregnancy and timely onset of labor after removal of the fetus. Amer. J. Physiol. 129:485.

Wagner, W. C. 1972. Induced parturition in cattle. Proceedings of Short Course for Veterinarians. Colo. State Univ.

Wagner, W. C., R. L. Willham and L. E. Evans. 1971. Induced parturition in the beef cow. J. Anim. Sci. 33:1164.

Wagner, W. C., R L. Willham and L. E. Evans. 1974a. Controlled parturition in cattle. J. Anim. Sci. 38:485.

Wagner, W. C., R. L. Willham and L. E. Evans. 1974b. Hormonal mechanisms controlling parturition. J. Anim. Sci. 38:39.

Welch, R. A. S., P. Newling and D. Anderson. 1973. Induction of parturition in cattle with corticosteroids: An analysis of field trials. N.Z. Vet. J. 21:103.

Wiltbank, J. N. 1972. Management of heifer replacements and the brood cow herd through the calving and breeding periods. In. C. C. O'Mary and I. A. Dyer (Ed.). Commercial Beef Cattle Production. Lea and Febiger, Philadelphia.

Wiltbank, J. N. 1973. Induction of parturition in beef cows. Simmental Shield. March-April:84.

Wright, J. M., I. Setlergren, R. R. Sootman and W. Hansel. 1970. Peripheral plasma progesterone levels in pregnant cows treated with flumethasone. Soc. Study Reprod., 3rd Ann. Meeting, Columbus, Ohio. 32.

Zerobin, K., W. Jöchle and C. Steingruber. 1973. Termination of pregnancy and protaglandin E_2 (PGE_2) $F_{2\alpha}$ ($PGF_{2\alpha}$) in cattle. Prostaglandis 4:891.

MONTANA STATE UNIVERSITY LIBRARIES
3 1762 10022704 8

N378
W733 Winter, James Larry
cop.2 Induced calving in
beef production

NAME AND ADDRESS
SEP 2 '74 INTERLIBRARY LOAN
JAN 31 [illegible] Ted Flynn (G) 74-6
Townsend, Mont
FEB 13 [illegible] K.A. Ranson
Dicki Hawk
521 W. Lo
Duckstage
Bill G

N378
W733
cop. 2