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RESULTS OF OREGON'S HEIFER DYSTOCIA STUDY[1]

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Introduction

Attempts to increase beef production by breeding heifers to calve at 2 years of age have yielded variable results. In the absence of dystocia (difficult or delayed parturition), heifers calving first as 2-yr-olds have a tendency to calve earlier in subsequent years, wean heavier calves, and produce a higher percent calf crop than heifers calving first as 3-yr-olds (Lesmeister et al., 1973). However, heifers at first calving are 3-4 times more likely to suffer dystocia than at second and later calvings (Meijering, 1984). Doornbos et al. (1984) reported 2-yr-old heifers experienced prolonged labor and required nearly 1.5 times as much assistance during parturition compared to mature cows. Consequences of dystocia may include increased calf mortality (Anderson and Bellows, 1967), reduced conception at subsequent matings (Laster et al., 1973), and increased calving intervals (Brinks et al., 1973).

Numerous factors have been examined as possibly influencing the frequency and severity of dystocia. Feto-pelvic incompatibility is likely the main reason for calving difficulty in heifers (Meijering, 1984). Calves with heavy birth weights and large frames experience more difficulty at birth than average sized calves (Ruttle et al., 1982; Doornbos et al., 1984). Precalving pelvic area has been correlated to dystocia (Bellows et al., 1971; Deutscher and Zerfoss, 1983), and heifers with pelvic openings less than about 200 cm^2 are high risks for difficulty (Makarechian and Berg, 1983). Other factors positively correlated with dystocia are prolonged gestation, male calves, birth weight of the sire, and dam weight (Price and Wiltbank, 1978; Meijering, 1984).

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The objective of this research was to examine these relationships by determining the effects of heifer birth weight, heifer breeding weight, heifer pelvic area, heifer body condition, gestation length, calf birth weight, and sire birth weight on the incidence of dystocia among 2-yr-old commercial beef heifers.

Materials and Methods

Data were obtained on 872 first-calf heifers from 14 cooperating ranches throughout Oregon. Data collection concentrated on spring-calving (Jan-Apr) herds. Heifers were of various breeding and management systems, but were bred to calve at 22-25 mo of age. The following variables were recorded immediately prior to the breeding season: heifer age, birth weight, internal pelvic area (pelvic height X pelvic width), condition score, and weight. All pelvic measurements were taken by a single technician using a Rice Pelvimeter. Condition scores ranged from 1-9 (emaciated - extremely fat) and were estimated by palpating subcutaneous fat over the backbone, ribs, and tailhead. The following data were collected by cooperating ranchers at time of parturition: calf birth date, birth weight, sex, and severity of dystocia. Calves were weighed within 24 h after birth. Severity of dystocia was scored from written descriptions of the birthing process as follows: 1-no difficulty, birth unassisted; 2-slight difficulty, non-mechanical assistance required; 3-considerable difficulty, hard pull by hand or mechanical assistance required; 4-extreme difficulty requiring caesarean section; and 5-malpresentation of calf (deleted from statistical analysis). Additional data recorded were gestation length and sire birth weight.

Simple correlation coefficients were calculated between all variables. Calf sex was coded 1 for male and 2 for female. One-way analysis of variance was utilized to test the effects of pelvic area, heifer condition score, heifer prebreeding weight, calf birth weight, pelvic area/calf birth weight ratio (PA/Bwt), and gestation length on severity of dystocia. Ranches were utilized as blocks in a randomized block design. Tukey's procedure (Steel and Torrie, 1960) was used to dis-

tinguish differences among dystocia score groups within variables ($P<.05$). Chi-square was used to test the null hypothesis that dystocia occurred in equal proportions among heifers having above and below mean pelvic areas, calf birth weights, and prebreeding weights.

Results and Discussion

Dystocia occurred in 34% of the heifers observed, and ranged from 19-69% among cooperating ranches. Among heifers suffering dystocia, 49% experienced slight difficulty, 41% considerable difficulty, and 5% required caesarean sections. The remainder (5%) experienced malpresentation of their calves and were excluded from further analysis. When examined prior to breeding, heifers averaged 13 mo of age, and ranged from 11-15 mo.

Variables significantly ($P<.05$) correlated with severity of dystocia were heifer birth weight, calf birth weight, calf sex, and PA/Bwt ratio (table 1). Birth weight of calf and pelvic area of dam most influence ease of calving in heifers (Meijering, 1984). However, our study demonstrated little correlation between pelvic area and dystocia (-.01). Pelvic area ranged from 100-271 cm^2 and did not have an effect ($P>.05$) on dystocia scores (table 2). Further, mean pelvic area of heifers calving unassisted was 177 cm^2; well below the 200 cm^2 suggested by Makarechian and Berg (1983) as the threshold of increased calving difficulty. The observed incidence of all dystocia did not differ ($P>.05$) from the expected for heifers with above or below mean pelvic areas (table 3, case 1). Data in table 3 (case 4) also indicate that when a heifer with a larger than average pelvic area gave birth to a calf below the mean birth weight, the incidence of dystocia was 19%. However, when the pelvic area was below the average, and birth weight above (case 5), the incidence of dystocia roughly tripled to 60%; significantly higher ($P<.05$) than expected.

Increasing calf birth weight had an effect ($P<.05$) on the severity of dystocia (table 2). Unassisted calves averaged 68 kg, and those exper-

iencing dystocia averaged 82 lb. Calves with above average birth weight experienced 52% dystocia while those below average had only 20% (table 3, case 2). Increasing birth weight has frequently been associated with dystocia (Doornbos et al., 1984; Makarechian and Berg, 1983; Price and Wiltbank, 1978). Important factors directly correlated with calf birth weight were heifer birth weight, heifer prebreeding weight, sire birth weight, and gestation length (table 1). This table also indicates inverse correlation between calf sex and birth weight. Calf sex was inversely correlated with dystocia, indicating males experienced dystocia more frequently than females.

The synergistic effect of pelvic area and calf birth weight was expressed in PA/Bwt ratio. The ratio had a higher correlation to dystocia than pelvic area, but not as high as calf birth weight (table 1). The PA/Bwt ratio averaged 2.6 for unassisted birth, but decreased ($P<.05$) with increasing severity of dystocia (table 2). In a study conducted by Deutscher and Zerfoss (1983), major calving difficulty was experienced when the ratio approached 3.0. In this study, the same severity of dystocia was reached when the ratio approached 2.0.

Condition scores did not differ ($P<.05$) among dystocia scores (table 2), but were inversely correlated with gestation (table 1). However, under-conditioned or over-conditioned heifers may experience frequent dystocia (Meijering, 1984). Assuming palpable subcutaneous fat reflects the level of nutrition, this correlation indicates the importance of adequately feeding gravid heifers. Condition scores ranged from 3-6, with no emaciated or fat animals observed. In this study, gestation did not vary ($P>.05$) among levels of dystocia severity (table 2). Gestation was, however, inversely correlated with heifer prebreeding weight ($P<.05$) (table 1).

Prebreeding weight of heifers did not have an effect ($P>.05$) on dystocia (table 2), but was moderately correlated with pelvic area

(table 1). Heifers with prebreeding weights above the mean experienced dystocia 39% of the time and those below 40% (table 3). Increasing sire birth weight was moderately correlated with calf birth weight and female calves, but was not significantly ($P>.05$) correlated with dystocia (table 1).

In Table 4 the incidence of dystocia with varying birth weights and pelvic sizes is documented. A strong relationship between calf birth weights and dystocia is evident as dystocia increases from 14% to 80% as birth weight increases from <60 pounds to over 90. Heifers having calves weighing 100 or more pounds all experienced dystocia. There is very little difference in dystocia rates with different pelvic sizes indicating a weak relationship between pelvic size and dystocia. However, it does appear that with the heavy calves (770 lbs) heifers with >180 cm^2 pelvic measurements experienced somewhat less dystocia. These results would indicate that selection or culling for pelvic size would have little effect on dystocia, whereas breeding for small calves would create a very drastic reduction in dystocia.

In conclusion, data on 872 first-calf heifers and their calves indicate calf birth weight was the primary factor influencing dystocia. When heifers with below average pelvic areas give birth to heavy calves, the incidence of dystocia can be expected to increase. Results indicate that breeding for lighter birth weights will dramatically reduce incidence of dystocia. Pelvic area alone did not differ ($P<.05$) among heifers, regardless of dystocia. Heifer management systems designed to reduce calf birth weight may reduce the incidence or severity of calving difficulty. Factors associated with heavy calves at birth were heavy parents, male calves, and prolonged gestation.

Summary

Breeding heifers to calve at 2 years of age can increase beef production. However, heifers at first calving are prone to dystocia, the consequences of which may reduce beef production. The objective of this

study was to examine the relationships among factors which may be associated with dystocia in beef heifers. Data were obtained on 872 first-calf heifers from 14 cooperating ranches throughout Oregon. Dystocia occurred in 34% of the heifers observed, and ranged from 19-69% among ranches. Among heifers with dystocia, 49% experienced slight difficulty requiring the calf to be pulled by hand; 41% experienced considerable difficulty requiring a hard pull; and 5% required caesarean sections. Variables significantly correlated ($P<.05$) with severity of dystocia and the corresponding r values were heifer birth weight (.14), calf birth weight (.35), calf sex (-.22), and the heifers pelvic area/calf birth weight ratio (-.17). Pelvic area was not different ($P>.05$) between heifers experiencing dystocia and those calving on their own. However, when a heifer with a pelvic area below the herd mean gave birth to a calf with a birth weight above the herd mean, the observed incidence of dystocia was greater ($P<.05$) than expected. Cattle management systems designed to reduce calf birth weight may reduce the incidence or severity of calving difficulty. Among factors significantly ($P<.05$) associated with calf birth weight and the corresponding r values were gestation length (.17), sire birth weight (.25), calf sex (-.22), heifer birth weight (.37), heifer prebreeding weight (.38), and pelvic area (.15).

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TABLE 1. CORRELATION COEFFICIENTS (r) AMONG VARIABLES

Variable	Heifer birth wt. (n=285)	Pelvic area (n=1177)	Heifer cond. score (n=1177)	Heifer prebreeding wt. (n=461)	Calf birth wt. (n=821)	Calf sex[a] (n=873)	Dystocia score (n=878)	Gestation length (n=194)	Sire birth wt. (n=63)
Heifer birth wt.	1.0								
Pelvic area	-.25[b]	1.0							
Heifer condition score	.11	.21[b]	1.0						
Heifer prebreeding wt.	.27[b]	.31[b]	.41[b]	1.0					
Calf birth wt.	.37[b]	.15[b]	.09[b]	.38[b]	1.0				
Calf sex[a]	.07	.02	.00	.00	-.22[b]	1.0			
Dystocia score	.14[b]	-.01	.02	-.08	.35[b]	-.22[b]	1.0		
Gestation length	-.09	.10	-.34[b]	-.30[b]	.17[b]	-.07	-.03	1.0	
Sire birth wt.	.36	-.38	-.01	.39	.25[b]	.26	.06	--	1.0
PA/Bwt ratio[c]	-.13[b]	.52[b]	.13[b]	.03	-.65[b]	.16[b]	-.17[b]	-.40[b]	

[a] Calf sex coded such that 1 = male, 2 = female.

[b] Values significant (P<.05).

[c] PA/Bwt ratio is pelvic area divided by calf birth weight (Deutscher and Zerfoss, 1983).

TABLE 2. VARIABLE MEANS BY DYSTOCIA SCORE GROUPS

Variable	Dystocia Score[a] 1	2	3	4
No. heifers	575	147	131	18
Pelvic area (cm^2)	177	178	174	173
Heifer condition score	5.0	5.1	5.0	4.8
Heifer prebreeding weight (lb)	635	639	639	615
Calf birth weight (lb)	68[b]	75[c]	82[d]	86[d]
Pelvic area/birth weight ratio	2.6[b]	2.3[c]	2.1[d]	2.0[d]
Gestation length (days)	286	287	290	288

[a] 1 = no assistance; 2 = light assistance (hand pull); 3 = hard pull; 4 = caesarean section.

[b,c,d] Means in rows with different superscripts are significantly different ($P<.05$).

TABLE 3. RESULTS OF CHI-SQUARE ANALYSIS TESTING EQUAL OCCURRENCE OF DYSTOCIA IN HEIFERS WITH ABOVE AND BELOW MEAN PELVIC AREA, CALF BIRTH WEIGHT, AND PREBREEDING WEIGHT

Case No.	Variable	n	Percent dystocia observed	Percent dystocia expected
1.	Above mean pelvic area	417	31	35[ns]
	Below mean pelvic area	455	39	35[ns]
2.	Above mean calf birth wt.	399	52	35**
	Below mean calf birth wt.	428	20	35**
3.	Above mean heifer prebreeding wt.	186	39	39[ns]
	Below mean heifer prebreeding wt.	150	40	39[ns]
4.	Above mean pelvic area and below mean calf birth wt.	192	19	40**
5.	Below mean pelvic area and above mean calf birth wt.	196	60	40**

[ns] Not significantly different ($P>.05$) than observed value.

** Differs significantly ($P<.05$) from observed value.

TABLE 4. INCIDENCE OF DYSTOCIA WITH VARYING BIRTH WEIGHTS AND PELVIC SIZE (%)[a]

Pelvic size (cm^2)	Birth weight (lb)					
	>90	80-90	70-80	60-70	<60	
	----------%----------					%
<140	-	64	38	17	0	32
140-160	100	67	50	20	9	41
160-180	82	62	31	19	27	36
180-200	68	47	24	31	13	33
200-220	100	51	31	9	13	35
>220	67	46	31	29	0	31
	80	56	33	20	14	35

[a] Numbers within the table represent the percentage dystocia, i.e. heifers with pelvic areas of 160-180 cm^2 and having calves weighing between 70 and 80 pounds experienced a dystocia rate of 31%.

The Effects and Mode of Action of Growth Promotants

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A major problem facing the livestock industry is the overproduction of fat. It is estimated that 15-20 billion pounds of fat are trimmed from carcasses in the U.S. annually. Relative to muscle tissue, which is 70% water, adipose tissue is calorically dense (80 - 90% lipid) and, consequently, expensive to deposit. Approximately three times as much energy is required to deposit adipose tissue compared to muscle (Figure 1).

Considering the inefficiency of adipose deposition and the consumer's desire for leaner cuts of meat we should consider means by which further reduction of carcass fat could be achieved. Considerable progress towards this goal has been made over the past four decades (Table 1); however, further reduction in carcass fat may be possible. A minimum body fat content of 20% is needed for maintenance of normal physiology of the animal. Consequently total fat production could still be reduced by as much as 30 - 40% without adversely affecting homeostasis.

Traditionally livestock producers have modified carcass composition in livestock species through management of the diet and genetic selection. Growth implants have been successful in stimulating rate of gain and efficiency of gain; however, they have limited impact on carcass composition. Recently pharmaceutical companies have developed a class of compounds, termed the beta-adrenergic agonists, for use in domestic species. These compounds effectively stimulate carcass protein accretion and inhibit adipose tissue deposition and therefore indicate potential as repartitioning agents for commercial use.

The beta-adrenergic agonists have been used in human medicine as bronchial dilators and smooth muscle relaxants. The have structures similar to the endogenous cathecholamines; epinephrine and norepinephrine (Figure 2); however, their effects appear to be more potent and longer-lasting. Their effects are thought to be mediated via interaction with beta-receptors on the target cell membranes (muscle and adipose) with intracellular events similar to those resulting from interactions with endogenous catecholamines.

Recent studies have evaluated the effects of a beta-adrenergic agonist clenbuterol (see Figure 2 for structure) on performance of beef steers (1), lambs (2), pigs (3), and broiler chicks (4). In all of these studies major repartitioning actions of clenbuterol were reported. In the beef steer study clenbuterol was fed as a top-dressing to 24 Hereford steers (initial weight was 350 kg) at levels of 0, 10 or 500 mg per head per day. Animals were maintained on feed for 98 days. Initially clenbuterol caused some off-feed problems and rates of gain were therefore limited (Table 2). Overall efficiencies and rates of gain were not significantly influenced by dietary clenbuterol; however, kidney, pelvic and heart fat were reduced at both clenbuterol levels. Clenbuterol stimulated muscling, estimated by longissimus dorsi area, and improved USDA yield grade (Table 2). Clenbuterol increased total body protein and lowered

total body fat content (Table 3). Carcass water was increased in clenbuterol-fed animals since muscle consists of a higher proportion of water relative to adipose tissue (Figure 1).

In an additional study 20 lambs (41 kg initial weight) were used to evaluate the effects of feeding 0 versus 2 ppm clenbuterol on carcass conposition and animal performance. Animals were maintained on experimental diets for 8 weeks with no off-feed problems. Clenbuterol increased average daily gain of the lambs by 24%, improved feed per gain ratio by 19%, increased dressing percent by 4.8%, increased semitendinosus muscle mass ny 23% and longisimus dorsi area by 41% (Table 4). Kidney and pelvic fat depth were reduced by 33% and 37% respectively. Clenbuterol increased hindquarter protein by 7.5% and reduced hindquarter fat deposition by 18% (Table 4).

The latter study was one of three which evaluated the effects of clenbuterol on lamb performance (2). Improvements in efficiency of gain were noted in two of the three studies; however, similar changes in lamb carcass composition were reported in each of the three studies. Similar responses to dietary clenbuterol have been reported for pigs and broiler chickens (3, 4); however, less clenbuterol was required to elicit these responses. Clenbuterol increased total carcass protein by 12.3% in barrows but had no effect on carcass protein in gilts (Table 5). Dietary clenbuterol reduced carcass fat in barrows and gilts by 13% and 9.9% respecvtively and stimulated both rates of gain and efficiencies of gain in broliers fed .25 and 1.0 ppm clenbuterol (Table 6). Clenbuterol enhanced total carcass protein deposition in female but not in male broilers; however, it reduced carcass fat deposition in broilers of both sexes.

Sites of Action of Beta-Adrenergic Agonists

There are numerous levels at which beta-adrenergic agonists could act to allow for their repartitioning actions. Since the natural catecholamines increase blood flow to muscle tissue it is possible that the actions of the synthetic catecholamines may mimic this function and thereby provide limiting nutrients for muscle growth. Although the vasodilatory properties of these agents are well-documented (5) it is not known whether increased blood flow, or increased nutrient supply, to muscle tissue would increase muscle protein accretion. Alternatively, the beta-adrenergic agonists could increase availability of amino acids, the so-called "building blocks" of protein, to the muscle cell by enhancing amino acid transport. Administration of the natural catecholamine; epinephrine, in vivo enhanced amino acid uptake by rat diaphragm muscle by 32 to 46% (6). If availability of amino acids intracellularly was normally limiting rates of protein synthesis, this effect, if it occured in domestic species, could account for increased muscle protein accretion. Catecholamines, such as epinephrine and norepinephrine, directly alter the metabolism and rates of protein turnover in skeletal muscle tissue. Isoproterenol, a beta-adrenergic agonist, and epineprine, when incubated with rat skeletal muscle decreased rates of protein degradation by 20%, increased muscle glycogen utilization by 40%, increased muscle lactate production by 50% and increased muscle oxygen utilization by 23% (7). Evidence also suggests that beta-adrenergic agonists may also increase muscle protein accretion by stimulating protein synthesis. Emery et. al. (8) reported that addition of clenbuterol directly to incubations of skeletal muscle stimulated rates of protein

synthesis. Actions of the agents on either protein synthesis or protein degradation could explain increased carcass protein accretion. Metabolic effects of the beta-adrenergic agonists are not limited to muscle. These compounds enhance adipose tissue lipolysis and elevate plasma free fatty acid concentrations (9). The availability of free fatty acids could spare amino acids from being broken down as energy sources in body tissues and thereby increase availability of amino acids for muscle growth.

Baile et. al (10) reported that low doses of isoproterenol, infused into the brains of sheep and cattle, stimulated feed intake. It is interesting to note that low levels of clenbuterol stimulated feed intake in broilers (Table 6) whereas high levels of beta-agonists inhibited feed intake in beef cattle Table 2). It is not known whether the reduction in feed intake was associated with an undesireable flavor or if the response was a physiological response to the agonist as a hormone.

At present there is considerable interest in the potential use of beta-adrenergic agonists commercially. However, efficacy, residue and toxicity testing needs to be completed. Optimistic estimates indicate that these agents could be approved for beef cattle witnin the next 4 - 5 years.

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Table 1. Changes in fat composition in domestic species in 40 years.

	Fat content[1]		
Year	Beef	Sheep	Pigs
1940	36-38%	44-48%	44-48%
1980	28-30%	28-30%	28-30%

[1] As % of carcass weight.

Table 2. Effect of clenbuterol on performance of steers.

	Clenbuterol (mg/head/day)		
	0	10	500
ADG (kg)	1.1	1.0	.87
ADI (kg)	13.0	12.1	10.3
F/G	11.9	12.0	12.0
Carcass weight (kg)	315.0	314.0	302.0
KPH fat (% BW)	2.52	1.93*	1.68**
Fat depth (cm)	1.29	.83**	.75**
Long Muscle Area	79.6	88.1*	92.6**
Marbling[1]	4.06	3.75	3.63
USDA yield grade	2.71	1.68**	1.20**

[1] marbling; 1=devoid, 9=abundant.
* P < .05 different from control.
** P < .01 different from control.
Source - Reference 1.

Table 3. Carcass composition for steers fed clenbuterol for 98 days.

	Clenbuterol (mg/head/day)		
Component	0	10	500
Protein	15.3	17.3**	17.5**
Fat	35.9	28.7**	25.3**
Water	47.7	52.4*	55.1**

* P < .05.
** P < .01.
Source - Reference 1.

Table 4. Effects of feeding clenbuterol on performance of lambs.

	Clenbuterol (ppm)		
	0	2	% change
Initial wt. (kg)	40.5	40.8	--
ADG (g/day)	212	263**	+24
F/G	8.31	6.72**	-19
Dressing %	54.6	57.2*	+4.8
Kidney and pelvic fat wt.	998	664*	-33
Semitendinosus muscle (g)	144	177**	+23
Fat depth (mm)	5.9	3.7**	-37%
Long. Dorsi Area (cm^2)	16.9	23.9**	+41
USDA yield grade	3.5	2.5**	-28
Hindquarter protein %	18.6	20.0**	+7.5
Hindquarter fat %	19.4	15.8**	-18
Hindquarter moisture %	59.1	62.5**	+5.8

* p .05.
** p .01.
Source - Reference 2.

Table 5. Effect of dietary clenbuterol on performance of swine.[1]

		Clenbuterol (ppm)		
Parameter	Sex	.05	.1	1
Loin eye area	Barrows	+9.1	+14.1*	+20.4**
	Gilts	+8.8	+8.8*	+24.5**
Semitendinous weight	Barrows	+7.7	+12.2	+17.1*
	Gilts	+6.6*	+4.1	+15.7**
Back fat thickness	Barrows	-4.9	-7.5	-6.9
	Gilts	-4.9	-16.4**	-8.5
Fat depth	Barrows	-6.4	-5.1	-15.0*
	Gilts	-8.8	-10.9	-9.5
Carcass protein	Barrows	+4.7	+10.5**	+12.3**
	Gilts	+.4	+3.1	+.3
Carcass fat	Barrows	-5.0	-6.8*	-13.0**
	Gilts	-8.1	-6.6	-9.9

[1] Values are expressed as percent deviation from control (0 ppm clenbuterol).
* P < .05.
** P < .01.
Source - reference 3.

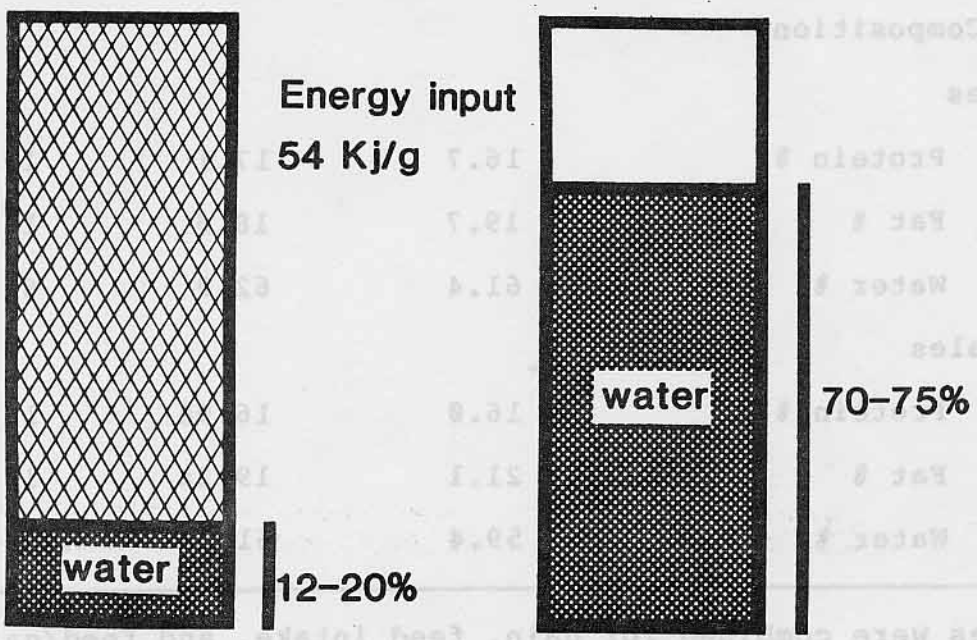
Table 6. Effect of dietary clenbuterol on performance of broilers

	Clenbuterol (ppm)			
	0	.25	1.0	4.0
Gain (28-49 days) g	1080	1123a	1124a	1103
Feed Intake (28-49 days), g	2350	2387a	2372	2358
Feed/Gain	2.21	2.14a	2.13a	2.15a
Body Composition				
Males				
Protein %	16.7	17.1	17.2	17.0
Fat %	19.7	18.0	16.6a	17.5
Water %	61.4	62.0	62.8	62.7
Females				
Protein %	16.0	16.9a	16.9a	17.0a
Fat %	21.1	19.2a	19.3a	19.2a
Water %	59.4	61.1a	61.7a	60.9a

Sexes were combined for gain, feed intake, and feed/gain.
a- significantly different from control ($p < .05$).
Source- Reference 4.

Fig. 1

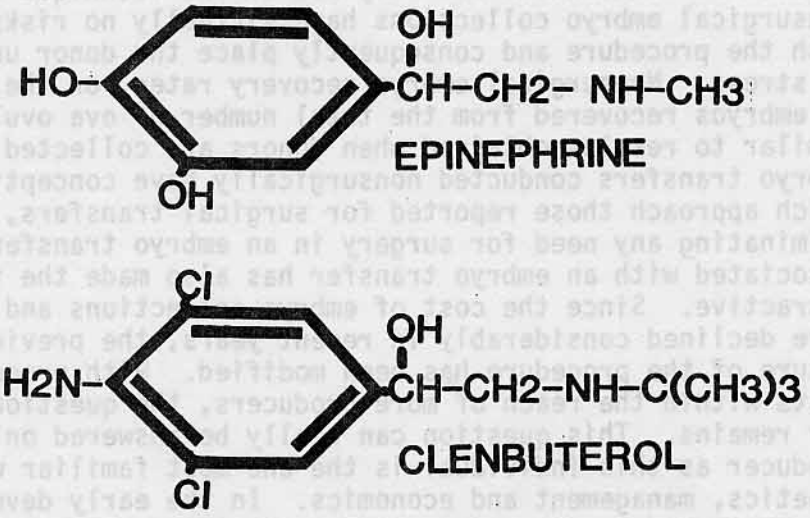
Energetics of adipose and muscle formation



840g x 54 Kj/g fat
45360 Kj/Kg adipose

275 x 54 Kj/g protein
14850 Kj/Kg muscle

Fig. 2


OH
HO-
CH-CH2- NH-CH3
EPINEPHRINE
OH
Cl
OH
H2N-
CH-CH2-NH-C(CH3)3
CLENBUTEROL
Cl

CURRENT APPLICATIONS OF EMBRYO TRANSFER

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The development of nonsurgical procedures in embryo transfer have allowed for convenient and easy use of the technique on the farm. Nonsurgical embryo collections have virtually no risks associated with the procedure and consequently place the donor under a minimum of stress. Nonsurgical embryo recovery rates, or the percentage of embryos recovered from the total number of ova ovulated, are similar to results obtained when donors are collected surgically. Embryo transfers conducted nonsurgically have conception rates which approach those reported for surgical transfers, thereby eliminating any need for surgery in an embryo transfer. The expense associated with an embryo transfer has also made the technique more attractive. Since the cost of embryo collections and transfers have declined considerably in recent years, the previously exclusive nature of the procedure has been modified. With procedures and costs within the reach of more producers, the question of applicability remains. This question can really be answered only by the producer as this individual is the one most familiar with the herd's genetics, management and economics. In the early development of embryo transfer, two major advantages were associated with the procedure. The first was that embryo transfer could dramatically increase a cow's reproductive rate by increasing the number of offspring produced by the female. Secondly, embryo transfer allowed for the propagation of individuals resulting from the selected matings of parents with genetic superiority in the production traits. These advantages are still available thru embryo transfer, however additional benefits have arose in recent years which have demonstrated merit in genetic progress and disease control.

Cattle have a low reproductive rate which suppresses both the accuracy and genetic progress possible in female selection. The amount of genetic progress obtainable with embryo transfer will never approach that realized by artificial insemination, but the potential increase in female reproductive rate available with embryo transfer can increase genetic progress. McDaniel and Cassell (1981) evaluated the impact of embryo transfer technology in three areas: production of bulls for progeny tests through artificial insemination, production of replacement females and progeny testing dams for milk yield. Genetic merit of bull dams could improve by as much as 17% if embryo transfer is applied to the generation of sires to be used for progeny testing. Sisters of these bulls would also be available for herd improvement. The genetic merit of dams of replacement females would also increase with embryo transfer. However, if increased production is the only

source of income from replacement females generated by embryo transfer then the use of this application is limited due to potential economic infeasibility. Use of the technique for progeny testing dams, however, has little advantage in genetic gain over selection based on the individual's performance and pedigree data. McDaniel and Cassell (1981) pointed out that although the economics of implementing the procedure were not thoroughly discussed, economic justification for the use of embryo transfer is paramount. Petersen and Hansen in Denmark (1977) have reported that the increase in genetic gain per year using embryo transfer in a bull path within a dual-purpose cattle population is only .22 percentage units. Economic returns generated from sons of elite cows, however, increased by approxmiately 20%. Bowen and coworkers (1978) have also shown that cows with some reproductive problems can be used as embryo donors and hence valuable genetic material can be conserved. Pregnancies resulted from embryos collected from donor cows with periovarian adhesions, oviductal obstructions and metritis. Similarly, several authors have reported on using embryo transfer to preserve genetic material from diseased cows. Embryos collected from cows seropositive to bovine viral diarrhea and infectious bovine rhinotracheitis are uninfected with these viruses (Singh et al., 1982a,b). Embryos from cows infected with bovine leukemia virus and bluetongue virus fail to transmit the disease to the recipients and hence these females and their offspring remain seronegative (Bowen et al., 1983; Eaglesome et al., 1982). Embryo transfer may also have application for propagating offspring from cows infected with brucellosis without transfering the disease (Stringfellow et al., 1982).

Field use of embryo transfer can efficiently produce increased calf crops. Renard and coworkers (1979) increased the calving rate from .83 to 1.16 per cow with embryo transfer. Current applications of increased twinning rate are of interest to increasing meat production in cattle herds.

Freezing embryos represents a viable means of conserving valuable domestic animal genes (Renard, 1984). Embryo cryopreservation can eventually lead to the creation of cattle embryo banks that could be used for the reconstitution or redevelopment of existing breeds. Conception rates using frozen embryos are 40-50% in cattle.

Embryo transfer also has application in the international movement of livestock (George, 1983). Shipment of embryos represents a convenient means for the international transfer of genetic material or livestock particularly with recent advances in cryopreservation transport of embryos could be used for new breed establishment, increasing herd numbers, breed improvement or herd repopulation.

One of the fundamental benefits of embryo transfer resides in the propagation of offspring from "elite" cows. Owners of "elite" or genetically superior cows could sell 10 to 40 offspring instead of the usual 3 to 4 per cow (Evans, 1980).

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GONADOTROPIN RELEASING HORMONE-INDUCED RELEASE OF LUTEINIZING HORMONE DURING THE MILK EJECTION REFLEX IN THE POSTPARTUM BEEF COW

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Introduction

Length of the postpartum anestrous period has been recognized as the most critical variable affecting the maintenance of an optimum calving interval. Suckling intensity of the calf (Wettemann et al., 1978; Randel, 1981) has been demonstrated to be a major factor contributing to the length of this reproductive stage of the cow. Although the precise manner by which suckling prolongs the postpartum period is not clearly understood, some evidence suggests that ovarian inactivity may be due to reduced secretion of gonadotropins from higher centers of the brain (Radford et al., 1978).

The effects of external stimuli on higher centers of the brain is displayed in figure 1. Suckling or milking stimuli cause an afferent signal to be sent to the hypothalamus in the brain. This signal causes a release of oxytocin that travels to the mammary gland and results in milk letdown. Oxytocin or the afferent signal itself may cause a reduction in gonadotropin releasing hormone (GnRH) release. Gonadotropin releasing hormone released from the hypothalamus acts on the pituitary to stimulate luteinizing hormone (LH) release. Luteinizing hormone in turn acts on the ovary during estrus to cause the release of the egg. Any mechanism interfering with the release of

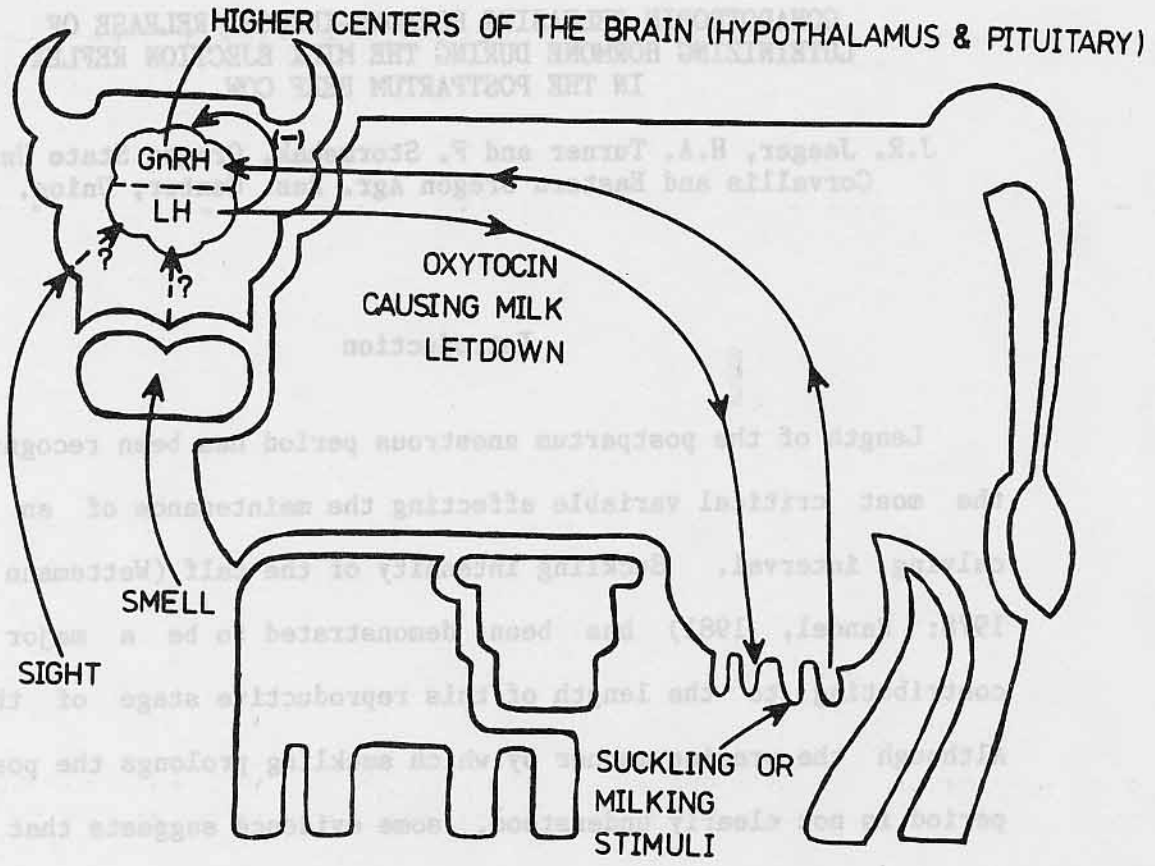

Figure 1. Stimulation of the udder elicits oxytocin release from the pituitary and results in milk letdown. Udder stimulation and possibly other external stimuli may also have an inhibitory effect on the higher centers of the brain. This inhibition could reduce essential reproductive hormones and result in absence of estrus and(or) poor conception.

either GnRH of LH will result in anestrus. Other environmental stimuli such as smell or sight of the calf may also cause a neural inhibitory effect on higher centers of the brain and reduce GnRH and(or) LH release.

Secretion of LH in the postpartum cow appears to be dictated in part by the frequency of suckling. Once daily suckling has been shown to result in a shorter postpartum anestrous interval (Randel, 1981; Reeves and Gaskins, 1981) and an increased LH release following GnRH injections (Troxel et al., 1980). More drastic reductions in suckling frequency, such as 48 h calf removal (Smith et al., 1977) or early weaning (Bellows et al., 1974; Carruthers et al., 1980; Walters et al., 1982a) also resulted in elevated serum levels of LH and a shorter postpartum interval. Suckling-induced suppression of LH secretion may not only be provoked by stimulation of the mammary gland but may also be due in part to a neural-hormonal mechanism triggered by the presence of the calf (figure 1). Peters et al. (1981) reported that serum LH concentrations began to rise about 2 weeks postpartum in milked cows, but remained low for an extended period in suckled cows.

Treatment of suckled cows with GnRH to cause the release of LH and reduce postpartum anestrous has been attempted with limited success (Echternkamp, 1978; Fernandes et al., 1978; Carter et al., 1980; Troxel et al., 1980; Smith et al., 1983). Administration of small intermittent doses of GnRH to mimic naturally occurring pulsatile GnRH release stimulates the release of LH and has been shown to cause suckled cows to cycle earlier than suckled controls, but later than weaned controls (Walters et al., 1982b). These

observations suggest that inhibition of LH release in suckled cows may be due in part to a suppression of GnRH secretion.

The act of suckling is known to have an immediate effect on the release of hormones by invoking the milk ejection reflex. Research to determine whether the act of suckling or the milk ejection reflex affects LH release through modification of the function of higher centers in the brain has not yet been conducted. The purpose of this study was to determine to what degree LH release is affected by suckling or the milk ejection reflex. Developing a new management technique that would shorten the interval from calving to conception was also desired.

Materials and Methods

Experimental Design. Twenty-four postpartum Simmental x Hereford cows having previously calved at least twice were assigned randomly to four groups with 6 per group. The groups and the treatments were as follows: group 1, suckled control (S+C); group 2, suckled+GnRH (S+GnRH); group 3, nonsuckled control (NS+C) and group 4, nonsuckled+GnRH (NS+GnRH). Treatment regimens are summarized in the following table:

Group	No. of Cows	Status	Injection
S+C	6	suckled	saline
S+GnRH	6	suckled	GnRH
NS+GnRH	6	nonsuckled	GnRH
NS+C	6	nonsuckled	saline

Calves were removed from all cows and isolated from the dam for 4 h on each of d 1 and 14 postpartum. After this isolation period, each calf was reunited with its dam in the S+C and S+GnRH groups and allowed to nurse for 5 min to permit the stimulation of the milk ejection reflex. The cows in the S+C and S+GnRH groups then received an iv injection of either saline or GnRH (200 ug), respectively. A dose of 200 ug of GnRH was chosen based upon the results of Webb et al. (1977), Echternkamp (1978) and Fernandes et al. (1978). Animals in the NS+C and NS+GnRH groups were treated similarly, except the calves were kept separated for an additional 2 h following the initial 4 h isolation period. To assess changes in serum LH, jugular blood samples were collected 15 min prior to the end of the 4 h calf isolation period, at the end of the isolation period (0 min), and at 15 min intervals for 120 min. All samples were collected between 1100 and 1700 h. The sampling regimen is summarized in figure 2. Upon completion of the 2 hour sampling period, the cow and calf were placed in a lot and allowed to remain together until d 14 postpartum when the treatment was repeated.

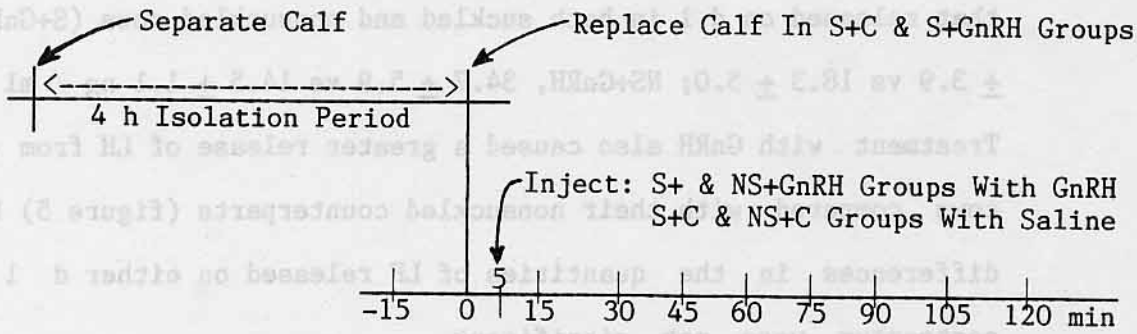

Figure 2. Calf removal, treatment and sampling regimens utilized on day 1 and 14 postpartum.

Serum was collected from each blood sample and frozen until completion of the study. Serum was then analyzed for LH concentration. The pituitary's response to GnRH was determined by computing the total quantity of LH released during the sampling period and subtraction of basal (background) levels. The resulting values were divided by 120 min to yield the quantity of LH released in response to GnRH per minute during the sampling period (ng LH / ml / min).

Results

Administration of GnRH to suckled and nonsuckled cows on d 1 or 14 postpartum provoked increased secretion of LH, with peak serum concentrations occurring from 105 to 120 min postinjection. The pattern of LH release on day 1 and 14 postpartum are displayed in figures 3 and 4, respectively. Regardless of the suckling status of the cow, response of the pituitary to GnRH increased with time from parturition. As shown in figure 5, the quantity of LH released in response to GnRH on d 14 postpartum was significantly greater than that released on d 1 in both suckled and nonsuckled cows (S+GnRH, 37.1 $\pm$ 3.9 vs 18.3 $\pm$ 5.0; NS+GnRH, 34.7 $\pm$ 5.9 vs 14.5 $\pm$ 1.1 ng / ml / min). Treatment with GnRH also caused a greater release of LH from suckled cows compared with their nonsuckled counterparts (figure 5) but the differences in the quantities of LH released on either d 1 or 14 postpartum were not significant.

Serum concentrations of LH in control cows did not differ due to

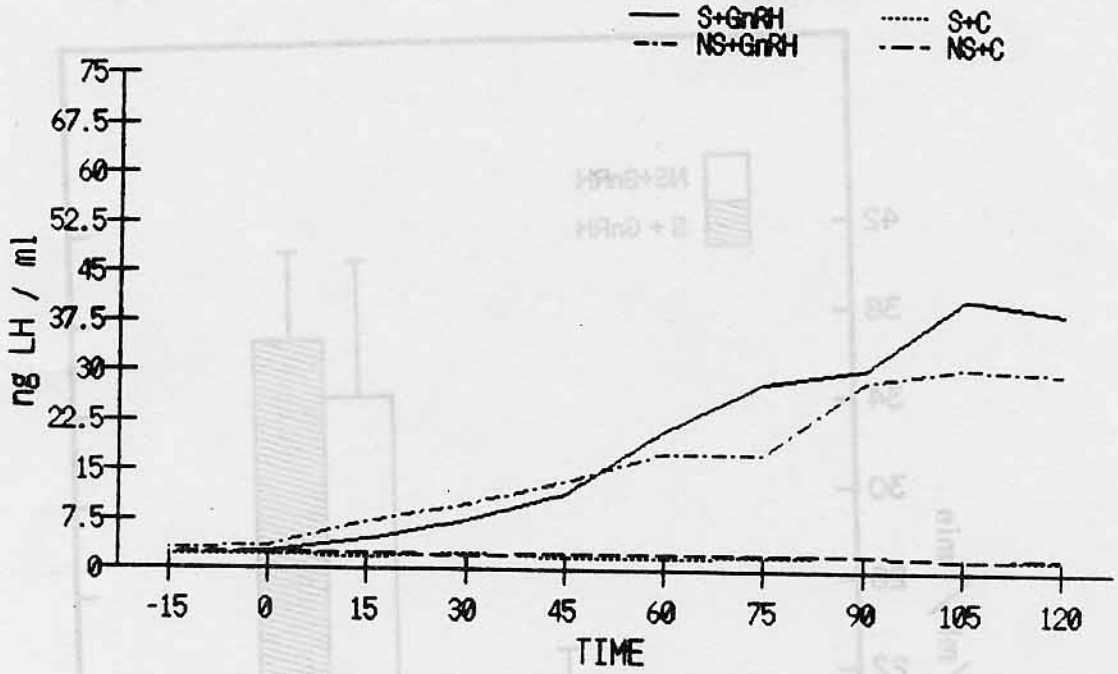

Figure 3. Pattern of LH release on day 1 postpartum following saline or GnRH treatment.

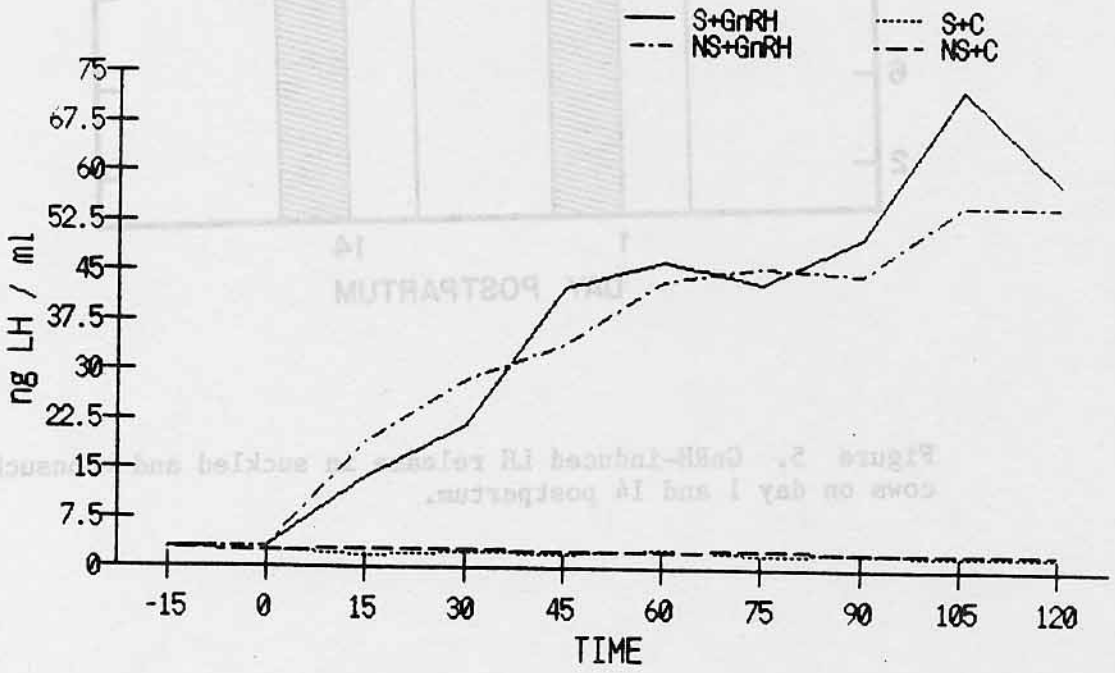

Figure 4. Pattern of LH release on day 14 postpartum following saline or GnRH treatment.

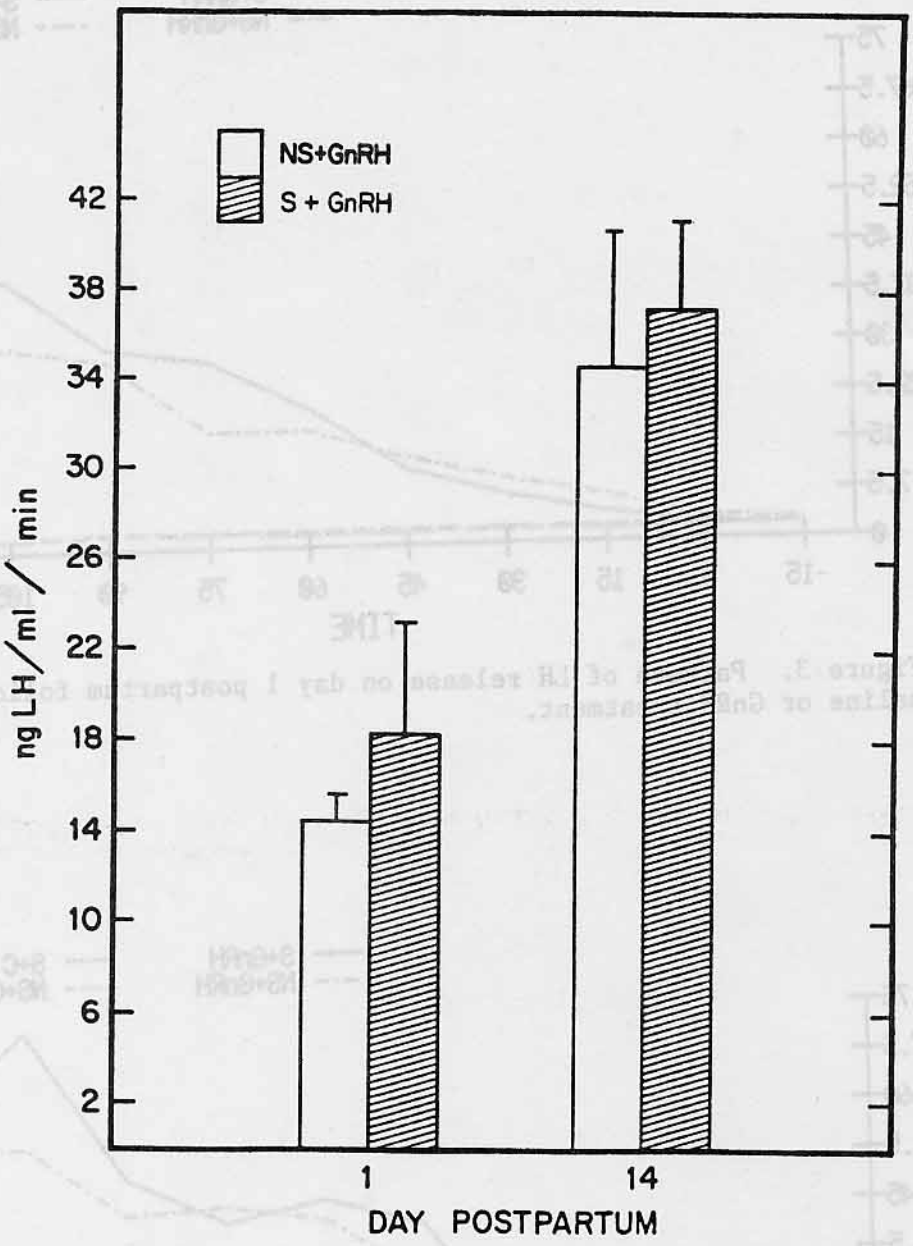

Figure 5. GnRH-induced LH release in suckled and nonsuckled cows on day 1 and 14 postpartum.

suckling or stage of the postpartum period and averaged 2.3 ± .1 ng/ml. In addition, there was no significant difference in pretreatment levels of LH between control or treated cows (2.3 ± .1 vs 2.9 ± .1 ng/ml, respectively).

On both d 1 and 14 postpartum only three of the six calves replaced with their dams in the S+GnRH group nursed during the sampling period. Nevertheless, milk ejection did occur in a majority of these "nonsuckled" S+GnRH cows as determined by the appearance of milk at the opening of the teat.

The treatment regimen utilized in this study had no effect on later reproductive performance. Interval to first estrus or conception was not affected by the suckling status of the cow. Additionally, administration of GnRH to suckled or nonsuckled cows did not affect the interval to first postpartum estrus or conception, which averaged 61±3 and 83 ± 3 d, respectively.

Discussion

Results of the present experiment indicate that the act of suckling or induction of the milk ejection reflex had no immediate effect on GnRH-induced LH release in cows on days 1 and 14 postpartum. Failure to detect an effect of the suckling stimulus may have been due to the short duration of isolation of the calf from its mother. The 4 h isolation utilized in this experiment may not have been sufficient to release the "brake" on LH secretion previously imposed by the calf. This possibility is supported by the data of Smith et al. (1983) who

found that cows separated from their calves an additional 8 h after 24 h calf isolation and treated with GnRH released more LH than those that were reunited with their young after the 24 h period. In agreement with the results of the present study, Williams et al. (1984) reported that manual stimulation of the teats of spayed nonlactating beef cows did not alter plasma LH levels or LH pulse frequency. However, it could be argued that stimulation of the teats of a nonlactating as opposed to a lactating animal would not be expected to elicit the same physiological response.

Quantity of LH released in response to GnRH in this study was greater on d 14 than on d 1 postpartum. In addition, the pattern of induced LH release in this experiment was similar to those reported to occur after intramuscular injection of GnRH into the postpartum cow at similar stages postpartum (Fernandes et al., 1978; Carter et al., 1980; Williams et al., 1982). Increased response to GnRH with increasing time from parturition has also been reported to occur in dairy cows (Kesler et al., 1977; Fernandes et al., 1978) and in suckled and nonsuckled beef cows (Williams et al., 1982). These data indicate that the ability of the pituitary to respond to GnRH increases with time from parturition in milked, suckled and weaned cows.

In conclusion, the data from the present study as well as those of studies cited above cast doubt upon the premise that it is the intermittent suckling stimulus per se that causes LH release to be suppressed during early lactation. Increased milk synthesis as the result of more frequent milk removal and(or) a neural-hormonal block

triggered by maternal behavior toward the calf appear to be more likely causes for the reduced secretion of LH. These latter possibilities are supported in part by the data of Carruthers and Hafs (1980) who found that dairy cows that were milked twice daily and suckled ad libitum release less LH and had an extended postpartum interval to ovulation compared with nonsuckled cows milked two or four times daily.

A technique has not yet been developed that will result in early conception following a reduced interval to first estrus. The incidence of low fertility has been observed to increase as the interval from parturition to first estrus is reduced. This reduced fertility is apparently more drastic in hormonally treated cows than in cows that are weaned early. Additional research is needed to further establish the role that the calf plays in influencing the length of postpartum anstrus.

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USE OF IONOPHORES IN COMMERCIAL BEEF CATTLE PRODUCTION

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INTRODUCTION:

Ruminant animals are unique in respect to their symbiotic relationships with digestive bacteria and protozoa. The host animal and rumen microbe interaction allows for utilization of low quality feedstuffs not suitable for human and nonruminant animals. While fermentation in the rumen is a definite advantage to the host animal, it has been the desire of ruminant nutrition researchers to manipulate rumen metabolism. It has only been within the past ten years that chemical agents have been utilized that offer significant potential for manipulation of rumen function. Among those chemical agents are ionophores, antibiotic drugs, that favorably affect the rumen microbial populations. The results are increased average daily gain (ADG) and more efficient feed utilization.

The goal of this paper is to define ionophores, to state how they benefit the animal and how they can be applied to commercial beef cattle production. Oregon State University has been active in ionophore research and a brief summary of the research completed will be presented.

Ionophores

Ionophores are compounds that facilitate the transport of ions across biological membranes. When fed to a ruminant animal in the proper amounts, ionophores inhibit the survival of many rumen microbes while benefiting other substrate limited microbes. As a result, ionophores alter the rumen microbial population and indirectly change rumen fermentation. Change in rumen fermentation is the primary factor leading to increased ADG and feed efficiency. The most common ionophores fed are:

	Trade Name	Produced By
Monensin-Sodium	Rumensin	Eli Lilly and Co.
Lasalocid-Sodium	Bovatec	Hoffmann-La Roche Inc.

Others: Salinomycin, Narasin, Avoparcin

Changes in Rumen Fermentation

One of the most often cited benefits of ionophores is the change in levels of volatile fatty acids (VFA), which are utilized for energy. In non-ruminants, glucose is the primary energy form that is metabolized. In ruminant animals, VFA's, specifically acetate, propionate and butyrate are the end products of microbial digestion. Ionophores have been shown to increase the amount of propionate at the expense of acetate (Dinius et al., 1976; Bartley et al., 1979; Thonney et al., 1981). This is important to the animal because propionate is more efficiently utilized for energy synthesis by the ruminant than either acetate or butyrate (Hungate, 1966; Chalupa, 1977).

Ionophores have also been shown to decrease ruminal protein digestions and ammonia (Fuller and Johnson, 1981; Darden et al., 1985). This allows high quality feeds to escape degradation in the rumen and pass to the abomasum and small intestine where they are more efficiently utilized.

Another change in rumen fermentation that is a benefit to the animal is the decrease in methane production. Depending on the feed type, eructation of methane gas represents 4-8% of the gross energy of the diet. Ionophores have been shown to decrease methane production to as much as 30% (Bartley et al., 1979; Thornton and Owens, 1981), which enables the host animal to utilize energy more efficiently.

There are many other ionophore induced changes in rumen fermentation that benefit the ruminant animal. With high concentrate (grain/energy) rations, ionophores increase ruminal pH and decrease lactic acid production (Nagaraja et al., 1983). This can be directly correlated to the reduction of lactic acidosis and grain bloat in feedlot rations. With cattle grazing pastures, ionophores have been shown to increase forage intake (Pond and Ellis, 1981) yet decrease the occurrence of grass/legume bloat. Ionophores have also been sited for the decreased occurrence of acute bovine pulmonary edema or emphysema with cattle on pasture (Potchoiba et al., 1982; Nocerni et al.,1985).

To the producer/feeder of beef cattle the important features of ionophores are increased ADG, improved feed efficiency and health of the herd. If used properly, ionophores can economically aid the producer in attaining these management goals.

RESEARCH TRIALS AT OREGON STATE UNIVERSITY:

Oregon State University has been active in conducting ionophore research for five years, and the emphasis has been the incorporation of ionophores into commercial beef cattle production schemes. Following is a brief summary of four research trials that have been completed:

Trial 1 - Graded Levels of Supplementation of Lasalocid. (1982)

The goal of this trial was to evaluate the performance of cattle with graded levels of ionophores. Sixty yearling steers were allotted to three treatments: 0, 50 and 100 mg lasalocid-sodium per head per day. The lasalocid-sodium was mixed in a finely ground grain carrier and hand-fed in bunks at two pounds per head per day. At the time of this trial, the most beneficial amount of lasalocid needed to yield maxiumum weight gain response was not firmly established. It was also unclear as to the palatability of high levels of lasalocid in small amounts of carrier grain.

Using the initial and final "shrunken" weights, the ADG for 0 mg, 50 mg and 100 mg treatments were 1.07, 1.12 and 1.25 pounds per head per day, respectively. While there was a numerical response with both lasalocid-sodium levels, only the 100 mg treatment level was found to be statistically significant. Lasalocid fed in the finely ground grain carrier was readily consumed indicating that the grain was an effective carrier.

In this trial, lasalocid caused a significant weight gain response when fed at 100 mg per head per day. Later research, however, established 200 mg per head per day as the optimum level of supplementation.

Trial 2 - Effect of Lasalocid on Fall Calving Beef Cows. (October 1983 to April 1984)

The purpose of this trial was to test the efficacy of feeding lasalocid to lactating beef cows. The following parameters were measured:

- cow weight changes and body condition.
- twelve hour milk production.
- percent milk fat and percent milk protein.
- actual calf weights and 205-day adjusted weaning weights.
- average days open (parturition to conception).

Lasalocid was fed in a finely ground grain carrier at 0 and 200 mg per head per day.

Results of this trial indicated that lasalocid had no significant effect on any of the measured parameters. While no apparent advantage was found by feeding lasalocid during this trial, dry matter intake could have been reduced. Likewise, no detrimental effects were observed in long term feeding of lasalocid to fall-calving beef cows.

Trial 3 - Supplementation of Lasalocid Via a Mineral Carrier. (May 1984 to August 1984)

This trial was conducted to evaluate the efficacy of feeding lasalocid in a salt-mineral carrier. Salt-mineral supplements are often used in commercial cattle operations. The use of them as carriers would add little if any additional cost to the producer.

Forty-two head of stocker cattle were allotted by weight and sex to two treatments. The control groups were fed Moorman's Range A mineral which contained 1440 grams lasalocid per ton of mineral (1.588 g lasalocid/kg mineral).

Throughout the course of this 84-day trial, consumption of the mineral was measured at 14-day intervals. Consumption of the control mineral was greater ($P<.05$) than the consumption of the mineral containing lasalocid (table 1).

Table 1. Consumption of Medicated and Non-Medicated Mineral Salt (kg).

Sex	Steer	Steer	Heifer	Heifer
Trial Status	Bovatec	Control	Bovatec	Control
Day 1-28	.15	.29	.12	.17
Day 29-56	.10	.13	.04	.20
Day 57-84	.07	.12	.05	.11
Day 0-84	.11.	.18	.07	.16

- consumption of Bovatec mineral = .09 kg/hd/day
- consumption of Control mineral = .17 kg/hd/day

The variable consumption pattern of the mineral treated with lasalocid can possibly be correlated with the lack of weight gain response (see table 2).

Table 2. Average Daily Gain (kg) of Stocker Cattle Consuming Medicated and Non-Medicated Mineral.

Treatment	Sex	ADG
Lasalocid	Total	1.22
	Heifers	1.11
	Steers	1.28
Control	Total	1.17
	Heifers	1.06
	Steers	1.23

While a slight numerical increase in ADG was observed in the lasalocid treated groups, this was not significant.

This research trial should not be interpreted as discouraging the use of lasalocid in mineral supplements. Instead, some manipulation of salt content and other palatibility factors should be considered to insure stable consumption over time. Muller et al. (1986) showed that by altering the salt content of supplements containing monensin, a 10% increase in ADG resulted. If consumption can be increased and variability decreased, significant weight gain responses can be obtained.

Trial 4 - Supplementation with Lasalocid Three Times Weekly to Stocker Cattle on Pasture. (April 1985 to August 1985).

Feeding lasalocid three times weekly is a practical approach to commercial stocker cattle production. Obviously, the goal of the commercial producer is to maximize profits and minimize costs. Feeding a grain supplement everyday to stocker cattle grazing on pasture can be labor intensive and costly. If the cost of supplementation is greater than the benefit derived, the motivation for the usage of lasalocid-grain carrier supplements is lost. If the amount of supplement fed and the frequency of feeding is decreased, the benefit of a lasalocid-grain carrier is increased.

Seventy-two head of yearling steers were allotted by weight to four treatments. Treatments consisted of: (1) .45 kg ground corn per head per day; (2) .45 kg ground corn per head three times weekly on Monday, Wednesday and Friday; (3) .45 kg ground corn with 200 mg lasalocid per head per day; (4) .45 kg ground corn with 467 mg lasalocid per head three times weekly. Both lasalocid treatment groups received the same weekly allowance of lasalocid (1400 mg lasalocid).

Lasalocid fed on an everyday basis increased (P<.Ø1) ADG over controls by 11 percent (see table 3). Lasalocid fed on an alternate day basis caused a numerical increase, however, this was not significant.

Table 3. ADG of Steers Supplemented with Lasalocid Everyday Versus Three Times Weekly.

Treatment	ADG (lbs)
Control everyday	2.47
Control 3X weekly	2.35
Lasalocid everyday	2.75**
Lasalocid 3X weekly	2.44

Least significant difference (LSD) @ .Ø1 alpha level.
** = P<.Ø1

SUMMARY

The supplementation of ionophores to cattle on pasture or range conditions is still an active area of research. The research at Oregon State University has indicated that feeding lasalocid in a hand-fed carrier seems to be the most practical means of supplementation. Supplementing lasalocid in a salt-mineral carrier yielded less than encouraging results and alternate day feeding does not appear practical at this point.

Research with monensin (rumensin) has been more successful in supplementing to cattle via a mineral carrier and on an alternate day basis. With the added advantage of manipulating salt content of the mineral, Muller et al. (1986) has reported a 1Ø percent increase in average daily gains. Monensin fed on an alternate day basis has also been reported to yield the same weight gain response as monensin fed on an everyday basis (Muller et al., 1986).

Lasalocid and monensin are approved for use in complete feedlot rations. They have also been approved for use in liquid supplements. With cattle on pasture, lasalocid and monensin are only approved for hand-fed grain carriers. Recent research reports indicate that monensin will be approved in the future for salt-mineral carriers and/or alternate day feeding schemes.

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