Exposure to ammoniated wheat straw as suckling calves improves performance of mature beef cows wintered on ammoniated wheat straw

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ABSTRACT: We studied how exposure to ammoniated wheat straw (AWS) early in life affected the performance of 32 mature crossbred beef cows (*Bos taurus*) (mean BW = 615 kg) wintered on AWS. Half (16) of these cows had been exposed as suckling calves to AWS for 66 d (Exposed), while the other 16 cows had no previous exposure to AWS (Naïve). Five years after the initial exposure, cows were stratified by BW and bred into 8 groups of 4 cows each. Exposed and Naïve cows occurred in each group, and groups of 4 cows were randomly assigned to one of eight pens. Cows were fed in these pens for a 150-d wintering period from December to May for 3 consecutive years. All cows were allowed ad libitum access to AWS and supplemented with alfalfa hay, vitamins, and minerals. Cows and their calves grazed irrigated meadow pastures for the remainder of the year. Cow BW and body condition score (BCS) were monitored monthly during the 3-yr study. Milk production was measured monthly from June to November of each year using the weigh-suckle-weigh technique. For all 3 yr, yearly average BW (P = 0.06, 0.03, 0.07) and BCS (P = 0.07, 0.001, 0.01) were higher for Exposed than Naïve cows. Postpartum interval (PPI) to rebreeding, monitored using consecutive calving dates, was shorter for Exposed than Naïve cows during yr 1 and 2 (P = 0.004 and 0.02, respectively), but similar in yr 3 (P = 0.19). Exposed cows also produced more milk than Naïve cows during yr 1 and 2 (P = 0.04 and 0.07, respectively), but milk production was similar in yr 3 (P = 0.74). Collectively, calves exposed to AWS briefly early in life performed better as cows when reexposed to AWS from 5 to 8 yr later in life. Thus, researchers and managers should consider previous exposure to low-quality forages (LQF) when assigning cattle to studies involving the use of LQF or when considering using LQF to reduce food costs.

Key Words: Beef Production, Feeding, Forage

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Introduction

Low-quality forages (**LQF**) offer potential to reduce the cost of livestock production. Unfortunately, intake and digestibility of LQF are low relative to animal requirements. Several techniques have been used to increase utilization of LQF by ruminants, including supplementation programs and chemical treatments (reviewed by Paterson et al., 1994). Biological methods, including incubation of LQF with ligninolytic organisms like white rot fungi, have shown some promise, but have received limited practical implementation (Reid, 1989). Some attention also has been given to genetic selection of plants that exhibit higher than normal digestibility of mature biomass, but agronomic problems have impeded their development (Cherney et al., 1991).

The ability of individuals to use LQF has received only limited attention. Heritabilities of 45% and 30% have been reported for cattle gains on feedlot diets and pastures, respectively (Taylor and Field, 1999). Unfortunately, the heritability of digestible dry matter intake (DDMI) of a LQF diet was only 20% in Hereford cattle (Wiedmeier et al., 1995). Thus, environmental factors account for most of the variability in the performance of cattle on LQF diets.

Efforts to increase use of LQF have ignored the potential importance of experience early in life on ability of cattle to use LQF. Nevertheless, brief exposure to LQF early in life can enhance intake of LQF by as much as twofold in both sheep (Distel et al., 1994, 1996) and goats (Distel and Provenza, 1991). Our objective was to determine how experience with LQF early in life influenced beef cow performance later in life when cows were wintered for long periods on LQF diets.

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Materials and Methods

Background

From a herd of approximately 140 beef cows, 64 cows were selected to evaluate the long-term effects of wintering on diets based on ammoniated wheat straw (**AWS**). The 64 cows were wintered from December to mid-May each year on AWS diets supplemented with alfalfa hay. They were fed the AWS diets through late gestation and early lactation. The remainder of the cows in the herd were wintered on an alfalfa-grass hay (AGH) diet. From mid-May to mid-October, both groups of cows and their calves grazed irrigated native meadow pastures. Thus, two types of weaning heifer calves were generated, and the only difference in their backgrounds was the winter diet of their dams, either AWS or AGH.

Replacement heifers were selected from dams wintered either on AWS or AGH. All weanling replacement heifers were reared in drylot on a total-mixed ration composed of AGH, corn silage, dry-rolled barley, and vitamin-mineral premix. All heifers calved first as 2-yr-olds and began calving approximately 30 d prior to the beginning of the calving period for the main cow herd.

After breeding in late April through May, all yearling replacement heifers grazed good-quality irrigated pastures. In the fall, pregnant coming 2-yr-old heifers were managed separately from the main herd and wintered on good-quality AGH. After calving, 2-yr-old heifers and their calves remained separate from the main herd and grazed good-quality irrigated pastures. After weaning their first calf, heifers were placed in the main herd.

Present Study

For this study, 4- to 5-yr-old cows (n = 32) were selected from the main herd. Cows were selected for large frame size (frame score 6 to 7), superior milking ability (9.1 kg/d), and moderately heavy muscling as part of an accelerated cow-calf production system utilizing irrigated pastures. The protocol of that study required the cows to be wintered (December through April) on AWS supplemented with alfalfa hay and a vitamin-mineral premix.

Half (16) of these cows had been exposed to AWS for 66 ± 3 d as suckling calves while their dams were wintered on AWS diets (Exposed). The other 16 cows had no exposure to AWS (Naïve) prior to this study.

Cows were mated for spring calving in March and April. On approximately May 20 of each year, estrus synchronization procedures began using the Syncro-mate-B system (Sanofi Animal Health, Inc., Overland Park, KS). Artificial insemination began the first week of June each year. This was timed with a monthly milk production measurement so that the calf removals associated with the weigh-suckle-weigh procedures would improve conception rates. Cows were artificially inseminated for 5-d following removal of the Norgestomet implants (Sanofi Animal Health, Inc.) after which a clean-up bull was placed with the cows for 45 d. Conception resulting from artificial breeding during the 3-yr study was 65, 72, and 80%, respectively.

Table 1. Winter feeding regimen for cows during late gestation and early lactation (December 1 to May 15) (dry matter basis)

	Dry matter consumed, $kg \cdot animal^{-1} \cdot d^{-1}$	
Period	Ammoniated straw	Alfalfa hay
Dec. 1 to Jan. 31	9.4	2.5
February	9.2	3.3
March 1 to May 15	8.9	4.1

Cows were wintered on an AWS-based diet, supplemented with alfalfa hay from December 1 to approximately May 15 each year. The amount of alfalfa hay offered was gradually increased to supply increasing protein and energy demands from late gestation through early lactation (Table 1).

Wheat straw was ammoniated using the stack method (Sundstøl and Coxworth, 1984), with the addition of anhydrous ammonia at 3% of DM in baled straw. Straw of the same variety of soft red winter wheat (*Triticum oestirum* 'Manning') was harvested from the same field each year. The straw was baled early in the morning to incorporate as much dew as possible to enhance the ammoniation process. Straw was treated in August of each year and stacks remained sealed until approximately 2 wk prior to feeding in early December when they were opened to allow dissipation of excess ammonia. Nutrient contents of the AWS and alfalfa hay used during each year of the study are presented in Table 2. Feeding periods for each of the 3 yr of the study were as follows: yr 1, December 5 through May 12; yr 2, December 3 through May 8; yr 3, December 2 through May 11.

Cows were wintered in drylot in 8 pens with 4 cows/pen. Pens were paved with concrete, and they had a sheltered loafing area at one end that allowed protection from wind and precipitation. Each pen had a covered feeder, at the end opposite the loafing area, that was separated into 4 feeding compartments, one for each cow. Although cows in a pen could move freely from one compartment to another, this arrangement allowed the feeding of small amounts of highly palatable supplements to each cow. Cows were stratified into pens based on BW and breed type. The breeding of the cows was the result of a 4-breed rotational crossbreeding program involving Angus, Gelbvieh, Hereford, and Tarentaise breeds. Because the primary objective was to study a cow-calf production system utilizing irrigated pastures, not previous exposure to AWS, Exposed and Naïve cows occurred in each pen: 6 of the pens had 2 Naïve and 2 Exposed cows each, 1 pen had 1 Naïve cow and 3 Exposed cows, and one pen had 3 Naïve cows and 1 Exposed cow. Cows calved in these pens.

Table 2. Nutrient composition of ammoniated wheat straw and alfalfa hay used to winter beef cows (dry matter basis)

	Year					
	1		2		3	
Nutr.	ALF[a]	AWS[b]	ALF	AWS	ALF	AWS
DM, %	87.6	83.2	89.2	85.5	91.1	86.2
CP, %	16.0	9.4	16.8	10.6	16.3	9.2
ADF, %	38.7	56.7	36.2	55.3	37.7	57.6
NDF, %	50.3	71.2	48.7	69.8	49.4	72.3
Ca[c], %	1.21	0.42	1.36	0.36	1.28	0.46
Phos[d], %	0.29	0.01	0.28	0.02	0.31	0.02

[a]Alfalfa hay.
[b]Ammoniated wheat straw.
[c]Calcium.
[d]Phosphorus.

Cows were fed daily at 1500. They were first offered 490 g DM/head of highly palatable vitamin-mineral supplement to correct deficiencies associated with the AWS-alfalfa hay diet (Table 3). The supplement was consumed quickly (1 to 2 min), which ensured that each cow received the appropriate amount. Next the AWS was weighed, delivered to each pen, and fed directly from bales without processing. The amount offered was based on the amount remaining the previous day. Cows were fed AWS to appetite with less than 2% orts. The daily allotment to each pen was evenly distributed to each of the 4 feeding compartments. Lastly, the appropriate amount of alfalfa hay was weighed and top-dressed on the AWS in each feeding compartment.

Cows were weighed and assigned a BCS at 30-d intervals the first week of each month just before feeding. Body condition scores were assigned based on the 1 through 9 system with a BCS of 1 representing emaciation and a BCS of 9 representing extreme obesity (Wagner et al., 1988). During the first 2 yr of the study, one person assigned all BCS. During yr 3 another individual, trained by the initial evaluator, assigned all BCS. Scorers were not aware of the treatments associated with this study.

At the conclusion of winter, cow-calf pairs grazed in common on irrigated pastures from approximately May 15 to November 1 each year. During the first week of each month, cows and calves were weighed and scored for body condition. In conjunction with each monthly weighing, milk production of the cows was estimated using the weigh-suckle-weigh method with two consecutive 12-h calf-removal periods (Dawson et al., 1960). Thus, milk production was estimated five times during each summer grazing period. All calves had free access to a cereal grain-based creep feed (25% oats, 25% barley, 35% corn, 10% soybean meal, 5% vitamin-mineral premix; 14.8% CP, 1.97 Mcal NE_m/kg, 1.34 Mcal NE_g/kg) during the summer grazing period.

The reproductive performance of the cows was assessed by the postpartum interval (PPI) to rebreeding. Since this was a long-term study, PPI was measured directly by consecutive calving dates assuming a 285-d gestation. During the first week of September each year, the cows were examined for pregnancy by a qualified veterinarian using rectal palpation. Any cows that did not conceive, or conceived too late to fit the desired calving window, were removed from the project and replaced. Selection of replacement cows was based on matching age and cow type of the other cows assigned to the project, i.e., large frame size, superior milking ability, and moderately heavy muscling. No consider-

Table 3. Ingredient and nutrient composition of mixture used to supplement beef cows wintered on ammoniated wheat straw-based diet (dry matter basis)

Item	Content
Ingredients, %	
Ground barley	48.06
Dicalcium phosphate	15.35
Dynamate[a]	8.00
Vitamin premix[b]	9.33
Mineral premix[c]	12.04
Salt	7.22
Nutrients	
Calcium, %	3.29
Phosphorus, %	3.03
Magnesium, %	1.03
Potassium, %	1.65
Sulfur, %	2.00
Sodium chloride, %	7.00
Zinc, mg/kg	745
Manganese, mg/kg	653
Copper, mg/kg	246
Iodine, mg/kg	24.0
Selenium, mg/kg	6.0
Cobalt, mg/kg	7.5
Vitamin A, kIU/kg	102.0
Vitamin D, kIU/kg	10.2
Vitamin E, IU/kg	616

[a]Magnesium, 11%; potassium, 18%; sulfur, 22%.
[b]Vitamin A, 1,100 kIU/kg; vitamin D, 110 kIU/kg; vitamin E, 6,600 IU/kg.
[c]Zinc, 6,000 mg/kg; manganese, 5,000 mg/kg; copper, 2,000 mg/kg; iodine, 200 mg/kg; selenium, 50 mg/kg; cobalt, 50 mg/kg.

Table 4. Effect of calfhood exposure to ammoniated wheat straw on yearly body weight change when mature cows were wintered on ammoniated wheat straw

	Year		
Monthly averages	1	2	3
December			
Naïve	625	641	660
Exposed	625	662	679
March			
Naïve	603	669	699
Exposed	662	705	723
June			
Naïve	606	620	648
Exposed	645	654	674
November			
Naïve	625	652	675
Exposed	654	675	687
$P > F$[a]	0.0001	0.0065	0.0921
SEM[b]	3.5	2.6	3.1
$LSD^{c}_{0.05}$	6.9	5.2	6.2
Yearly averages			
Naïve	615	645	671
Exposed	646	674	691
$P > F$	0.0568	0.0269	0.0722
SEM	11.3	8.7	7.6
$LSD_{0.05}$	23.1	17.9	15.6

[a]Probability greater than F score for treatment × date interaction.
[b]Standard error of mean.
[c]Least significant difference, $\alpha = 0.05$.

ation was given to previous exposure to AWS. During the first year of the study, 2 Naïve cows were replaced due to reproduction failure. One of these replacement cows was exposed to AW as a calf while the other was not. The second year another Naïve cow was replaced, due to reproduction failure, with a cow that did not have previous exposure to AWS.

Repeated measures analysis of variance was used to analyze the data—body weight, body condition, milk production, calf 205-d weight, and post-partum interval—using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). There were two treatments (Exposed or Naïve), and cows (n = 16/treatment) were nested within treatments. "Cows nested within treatments" was the error term for treatments. Measurement date within a year was the repeated measure. "Measurement date crossed with cows nested within treatments" was the error term for date and the treatment by date interaction. Conception rate data were analyzed using a chi-square test.

Results

Body Weight Change (Table 4)

At the beginning of the first winter-feeding period (December), the BW of Exposed and Naïve cows was nearly identical. By the end of gestation (March), Exposed cows had gained 37 kg, while Naïve cows had lost 22 kg, a 59-kg difference between the two groups ($P = 0.0001$). For the entire first winter feeding period (December to June), including late gestation and early lactation, Exposed cows gained 20 kg BW, while Naïve cows lost 19 kg BW. Thus, Exposed cows were 39 kg heavier than Naïve cows by the end of the first winter-feeding period.

During the first summer-grazing period (June to November), Naïve cows gained 10 kg BW more than Exposed cows. However, Exposed cows were still 29 kg heavier than Naïve cows at the end of summer. Thus, during the first production cycle, Exposed cows were on average 31 kg heavier ($P = 0.06$) than Naïve cows (646 vs 615 kg).

During the second gestation period (December to March), both groups of cows gained BW, but Exposed cows gained 15 kg more than Naïve cows ($P = 0.007$). Both groups of cows lost BW during the second winter-feeding period (December to June), but Naïve cows lost 13 kg more than Exposed cows (21 vs 8 kg). Both groups of cows gained BW during the second summer-grazing period, and Naïve cows gained 11 kg more than Exposed cows. However, Exposed cows were 23 kg heavier than Naïve cows by the end of the second summer ($P = 0.007$). By the end of the second yearly production cycle, Exposed cows were 29 kg heavier ($P = 0.03$) than Naïve cows (674 vs 645 kg).

Both groups of cows gained BW during the third gestation period, but Exposed cows gained more than Naïve cows (44 vs 39 kg) ($P = 0.09$). The magnitude of the difference in BW gain during the third gestation

Table 5. Effect of calfhood exposure to ammoniated wheat straw on yearly body condition score change when mature cows were wintered on ammoniated wheat straw

	Year		
Monthly averages	1	2	3
December			
Naïve	5.1	5.5	5.6
Exposed	4.8	5.7	5.8
March			
Naïve	4.5	5.1	5.5
Exposed	5.1	5.6	5.7
June			
Naïve	4.9	4.9	5.3
Exposed	5.4	5.5	5.6
November			
Naïve	5.2	5.4	5.7
Exposed	5.5	5.8	5.9
$P > F$[a]	0.0001	0.0001	0.3611
SEM[b]	0.056	0.043	0.048
$LSD^{c}_{0.05}$	0.11	0.09	0.10
Yearly averages			
Naïve	5.0	5.2	5.5
Exposed	5.3	5.6	5.8
$P > F$	0.0736	0.0008	0.0122
SEM	0.108	0.077	0.067
$LSD_{0.05}$	0.22	0.16	0.14

[a]Probability greater than F score for treatment by date of interaction.
[b]Standard error of mean.
[c]Least significant difference, alpha = 0.05.

was less than in yr 2 (5 vs 15 kg). Both groups of cows lost BW during the third winter-feeding period, but Exposed cows lost less than Naïve cows (5 vs 12 kg). The magnitude of difference between Exposed and Naïve cows was less in yr 3 (7 kg) than yr 2 (13 kg). Both groups of cows gained BW during the third summer-grazing period. Naïve cows gained more than Exposed cows (27 vs 13 kg), but by the end of the third yearly production cycle, Exposed cows still were 20 kg heavier ($P = 0.07$) than Naïve cows (691 vs 671 kg).

Body Condition Score (Table 5)

Calfhood exposure to AWS also influenced BCS. At the beginning of yr 1 (December), Naïve cows had slightly higher BCS than Exposed cows (5.1 vs 4.8). Naïve cows lost 0.6 unit BCS during the gestation period (December to March) in yr 1, and were below the suggested functional BCS of 5 at the beginning of calving (Wetteman, 1994). Exposed cows increased BCS 0.3 units during the same period and were slightly above the threshold BCS of 5 at the beginning of calving ($P = 0.0001$).

During the first winter-feeding period (December to June), Naïve cows lost 0.2 unit BCS while Exposed cows increased 0.6 unit BCS ($P = 0.0001$). Both groups of cows increased BCS during the calving/early lactation period (March to June). As with BW, the BCS of Naïve cows increased more than the BCS of Exposed cows (0.3 vs 0.1 unit BCS) during the first summer-grazing period (June to November). For the first yearly production cycle, Exposed cows had exhibited 0.3 unit higher BCS ($P = 0.07$) than Naïve cows (5.3 vs 5.0).

Naïve cows again lost 0.3 units BCS during gestation in yr 2, while Exposed cows lost only 0.1 unit BCS ($P = 0.0001$). However both groups were above the functional threshold of 5 at the beginning of calving (March). Unlike the first year of the study, BCS of both groups decreased during calving/early-lactation period in yr 2. Naïve cows lost 0.2 unit BCS while Exposed cows lost 0.1 units BCS. As in the first year, BCS of both groups increased during the summer-grazing period. The BCS of Naïve cows improved 0.5 units and that of Exposed cows 0.3 units. As in yr 1, Exposed cows had higher BCS ($P = 0.0008$) than Naïve cows (5.6 vs 5.2) throughout the second yearly production cycle. By the third year of the study, the treatment × date interaction for BCS was no longer significant ($P = 0.36$), but Exposed cows remained in higher BCS ($P = 0.01$) than Naïve cows (5.8 vs 5.5) throughout the production cycle.

Post-Partum Interval (Table 6)

A PPI to rebreeding of no more than 80 d is required to maintain a 365-d calving interval, a major reproductive goal in the beef cattle industry (van Oijen et al., 1993). During the first year, Exposed cows rebred within 81 d, while Naïve cows required 90 d ($P = 0.004$). During the second year, Exposed cows required 84 d to conceive, while Naïve cows required 92 d ($P = 0.02$). By the third

Table 6. Effects of calfhood exposure to ammoniated wheat straw on milk production, calf 205-d weight, and postpartum interval to rebreeding when mature cows were wintered on ammoniated wheat straw

	Year		
Month	1	2	3
Milk production, kg			
Naïve[a]	9.1	9.8	11.2
Exposed[b]	10.1	10.8	11.3
SEM[c]	0.84	0.53	0.48
$P > F$[d]	0.04	0.07	0.74
Calf 205-d weight, kg			
Naïve	296	316	344
Exposed	316	333	350
SEM	8.9	9.2	6.5
$P > F$	0.14	0.21	0.54
PPI, d[e]			
Naïve	90	92	82
Exposed	81	84	82
SEM	2.0	2.3	1.8
$P > F$	0.004	0.02	0.19

[a]Naïve = cows never before exposed to ammoniated wheat straw.
[b]Exposed = cows briefly exposed to ammoniated wheat straw as suckling calves only.
[c]Standard error of mean.
[d]Probability greater than F score.
[e]Postpartum interval to rebreeding.

year, PPI of Exposed cows was 82 d, while that of Naïve cows was 85 d (P = 0.19).

All Exposed cows became pregnant within 84 d of calving during the 3-yr study. However, of the 16 Naïve cows, 2 cows in yr 1 and 1 cow in yr 2 failed to become pregnant. All Naïve cows became pregnant within 85 d of calving in yr 3. Chi square analysis indicated that conception rates did not differ between the two groups (P = 0.25). The low number of cows limited the statistical power of the tests.

Milk Production (Table 6)

During yr 1 and 2, Exposed cows produced 1.0 kg more milk/d (P = 0.04 and 0.07, respectively) than Naïve cows (10.1 vs 9.1 kg; 10.8 vs 9.8 kg). By yr 3, both groups of cows produced similar (P = 0.54) amounts of milk (11.3 kg).

Calf 205-d Weight (Table 6)

The 205-d weight of creep-fed calves did not differ in any year of the study, although Exposed cows weaned numerically heavier calves than Naïve cows each year (P = 0.14, 0.21, and 0.54, respectively).

Discussion

Winter is usually the most costly period in the yearly production cycle of spring-calving beef cows. Increased intake of LQF during this period can reduce the cost of production for the herd. Increased intake of LQF enhances body weight and body condition of beef cows during calving, which markedly influences subsequent reproductive performance and milk production (Wetteman, 1994).

Exposing calves to AWS improved their performance as cows 5 to 8 yr later. Exposed cows maintained higher BW and BCS than Naïve cows throughout the year in all 3 yr of the study. Postpartum interval to rebreeding was shorter and milk production higher for Exposed than Naïve cows during yr 1 and 2 of the study, but similar in yr 3. The differences in this study are likely conservative, given that eating with experienced animals can markedly influence Naïve animals to consume otherwise unacceptable foods (Ralphs and Provenza, 1999).

These findings illustrate the marked long-term influence that exposure to foods early in life can have on performance later in life. Even though both groups of cows exhibited acceptable performance during yr 2 and 3 of the study, Exposed cows clearly showed superior performance. Under more stressful conditions, likely to be encountered in more practical production situations, Exposed cows would have an added advantage.

Influence of Experience—Year 1

The most profound effect of brief calfhood exposure on performance of mature cows occurred during the first year of the study. During the first gestation period (December to March), we estimated the NE_m requirement of these cows to be 13.34 Mcal/d (NRC, 1996).

During the first gestation period (December to March), Exposed cows gained 37 kg and improved in BCS by 0.3 unit. Somewhat higher BW gains were reported during a 60-d pre-calving period when beef cows were wintered on AWS supplemented with sorghum grain and soybean meal (Beck et al., 1992; Fike et al., 1995). However, we observed greater changes in BCS than in those studies, and BCS is a more reliable indicator of nutritional status than BW. Exposed cows began calving in early March in BCS of 5.1, slightly above the threshold suggested for optimal reproductive performance and milk production. Based on performance, Exposed cows were consuming 14.21 Mcal NE_m/d (NRC, 1996). On the other hand, Naïve cows were consuming only 11.96 Mcal NE_m/d (NRC, 1996). Since all cows were consuming the same amount of AH during this period, we assume Naïve cows consumed less AWS. Naïve cows began calving (March) with BCS 4.5, below BCS 5.0 considered to be optimal for PPI and subsequent milk production (Wetteman, 1994). Consequently Naïve cows required 9 more days to rebreed and produced 1.0 kg less milk/d than Exposed cows.

During the first 93-d calving/lactation period (March to June), BCS increased for Exposed and Naïve cows, even though cows were selected for superior milking ability and were suckling aggressive terminal calves. Beef cows can gain BW and perform satisfactorily when fed AWS supplemented with corn silage and various types of protein during mid- and late-lactation (De Gracia and Ward, 1991). The similarity in performance of the Exposed and Naïve cows may have been facilitated by an increase in the daily allowance of AH (3.3 to 4.1 kg DM/d). While milk production was not measured during this period, Naïve cows also may have been producing less milk than Exposed cows due to lower BCS at calving. Intake of AWS by Naïve cows may as well have increased due to contact with Exposed cows (Ralphs and Provenza, 1999). However, during the first winter-feeding period (December to June), BCS of Exposed cows improved by 0.6 unit, while that of Naïve cows decreased by 0.2 unit.

Both groups of cows gained BW and BCS during the first summer grazing period (June to November). However, Naïve cows gained more BW and increased BCS more than Exposed cows. This response may have been due to increased forage intake by Naïve cows, which would decrease pasture carrying capacity. Naïve cows produced less milk during this period so more energy could have been partitioned to BW and BCS gain. Finally, Naïve cows may also have been exhibiting a compensatory response to lower gains during winter (Freetly et al., 2000). Averaged throughout the entire first annual production cycle, Exposed cows were 31 kg heavier and 0.3 unit higher in BCS than Naïve cows.

Influence of Experience—Year 2

Compared to the first year, cows in both groups were heavier and in better condition the second year. Nevertheless, differences in BW and BCS carried over from the first year. At the beginning of the second winter-feeding period (December), Exposed cows weighed more (21 kg) and were in better body condition (0.2 BCS unit). Unlike the first year of the study, Naïve cows gained weight during the second gestation period (December to March), indicating ongoing adaptation to the AWS-based diet. Nevertheless, Exposed cows still gained more than Naïve cows during this period (43 vs 29 kg), and they gained the recommended 35 to 55 kg of BW prior to calving, whereas the Naïve cows did not.

Both groups of cows were in a better body condition at the end of the second gestation period (March) compared with the first. Exposed and Naïve cows were 0.5 and 0.6 unit BCS higher, respectively. Naïve cows had suboptimal BCS (4.5) in yr 1, and acceptable BCS (5.1) in yr 2. Exposed cows had acceptable BCS at the end of gestation both years (5.1 and 5.6, respectively). Even though Naïve cows performed better during gestation the second year, Exposed cows remained in superior body condition at the beginning of the calving/early lactation period (March) (5.6 vs 5.1).

Unlike the first year of the study, both groups of cows lost some condition during the second calving/lactation period (March to June). The AH and AWS used during the second year were of slightly higher quality than in the first year, so food quality probably does not account for the reduction in BCS (Table 2). However, a much colder and wetter second spring likely increased energy requirement. Average daily temperature during March and April of yr 1 and 3 was similar: 4.8 and 5.0°C, respectively. Average daily precipitation was also similar: 0.30 and 0.28 cm, respectively. However, during yr 2 average daily temperature and precipitation were 3.7°C and 0.56 cm, respectively.

For the winter-feeding period (December to June), both groups of cows lost weight and condition. However, Naïve cows lost more weight (21 vs 8 kg) and condition (0.6 vs 0.2 unit BCS) than Exposed cows. Both groups of cows weighed more at the end of the second winter-feeding period (June), but they ended the period in nearly the same body condition as the first year. The BCS at calving has a major influence on PPI and milk production. However, post-calving environment and nutrition also affect performance. Although Naïve cows were in BCS 5.1 at calving in yr 2 and 4.5 in yr 1, PPI was actually 2 d longer in yr 2. Exposed cows were in BCS 5.1 and 5.6 at calving in yr 1 and 2, respectively, yet PPI was 3 d longer in yr 2. The colder, wetter spring of the second year likely caused these differences. However, even under these more adverse conditions, the 0.4 unit higher BCS of Exposed at calving in yr 2 resulted in a PPI that was 8 d shorter. As a result of higher BCS at calving (March) and at the beginning of the summer-grazing period (June), Exposed cows produced 1 kg more milk/d than Naïve cows.

As in the first year, both groups of cows gained weight and condition during the summer grazing period, and Naïve cows gained more weight (32 vs 19 kg) and condition (0.5 vs 0.3 unit BCS) than Exposed cows. However, by the end of the second grazing season, Exposed cows were still in better condition (0.4 unit BCS) and weighed more (23 kg) than Naïve cows. Averaged throughout the second yearly production cycle, Exposed cows were 29 kg heavier and 0.4 unit BCS higher than Naïve cows.

Influence of Experience—Year 3

Differences in BW and BCS between Exposed and Naïve cows remained in yr 3. Yearly average BW and BCS were 20 kg and 0.3 unit higher for Exposed than Naïve cow. However, the magnitude of difference was diminished as indicated by the higher probability scores associated with the date × treatment interaction. This indicates continued adaptation to AWS by Naïve cows. No difference in PPI could be detected the third year, further indication of the adaptation of Naïve cows to AWS. Both groups were in excellent body condition at calving (March) and at the beginning of the summer-grazing period (June). As a result no difference in milk production could be detected the third year. This attests to the fact that cows in both groups had similar genetic potential regarding milk production, and differences detected the first 2 yr were due to differences in BW and BCS.

Influence of Experience—General

Experiences early in life influence foraging behavior. Herbivores learn foraging skills (Flores et al., 1989a,b; Ortega-Reyes and Provenza, 1993), and they learn preferences for foods (sheep—Nolte et al., 1990; goats—Biquand and Biquand-Guyot, 1992). Lambs exposed to wheat grain for 1 h/d for 5 d at 6 wk of age ate significantly more wheat 3 yr later as adults than did animals that never consumed wheat (Green et al., 1984). Brief exposure to low-quality forages early in life also enhanced intake of low-quality forages by as much as twofold in sheep (Distel et al., 1994, 1996) and goats (Distel and Provenza, 1991). Goats reared from 1 to 4 mo of age on blackbrush (*Coleogyne ramosissima*)-dominated land ate over 2.5 times more blackbrush than goats naive to blackbrush. Goats allowed to choose between the poorly nutritious blackbrush and alfalfa pellets preferred more nutritious alfalfa pellets, but experienced goats consistently ate 30% more blackbrush than inexperienced goats (Distel and Provenza, 1991). Experiences early in life cause neurological, morphological, and physiological changes that help animals better use low-quality forages (Provenza and Balph, 1990). These experiences influence preference and performance. Repeated exposure and food deprivation eventually overcome decreased intakes of low-quality foods, but that may require as many as 3 yr, as observed in the present study (reviewed in Provenza et al., 2002).

Implications

To reduce the cost of ranch operation, researchers and producers are exploring ways to feed low-cost foods such as ammoniated straw to livestock during winter. Our findings illustrate the importance of exposing cattle at an early age to nutrient regimens they may encounter later in life, especially if those regimens are likely to be challenging (i.e., low-quality forages). The cows in this study were protected from adverse environmental factors that may further enhance differences in normal production settings. They also were in their prime years of production capability. Effects on older or younger cows may be more pronounced. Finally, if the average generation interval in beef cattle is 7 yr, the 3-yr effects due to early exposure would account for nearly 43% of the productive life of the cows. Researchers and managers should consider previous exposure to low-quality forages when assigning cattle to studies involving the use of such forages or when considering using them to reduce food costs.

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