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Effect of late gestation bodyweight change and condition score on progeny feedlot performance

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Abstract. Inadequate nutrient intake during late gestation can cause cow bodyweight (BW) loss and influence cow reproductive performance and subsequent productivity of steer progeny. Therefore, a 7-year study with a 3 × 3 arrangement of treatments was conducted at Corona Range and Livestock Research Centre, Corona, New Mexico to evaluate the effects of cow BW change and body condition score (BCS) during late gestation on subsequent cow pregnancy rates, progeny steer feedlot performance, and health. Cows were retrospectively classified to 1 of 3 BW change groups: (1) cows that lost BW during late gestation (LOSS; mean –26 ± 2 kg); (2) cows that maintained BW during late gestation (MAIN; mean –1 ± 1 kg); or (3) cows that gained BW during late gestation (GAIN; mean 25 ± 2 kg). Cows were also classified to 1 of 3 BCS groups: BCS of 4 (mean BCS = 4.0 ± 0.02; range 4.0–4.5), 5 (mean BCS = 5.0 ± 0.02; range 5.0–5.5), or 6 (mean BCS = 6.0 ± 0.02; range 6.0–6.5). After weaning each year, steers were preconditioned for 45 days and were received and treated as custom-fed commercial cattle at a feedlot in mid-November. Calf weaning BW, initial feedlot BW, final BW, and hot carcass weight were unaffected ($P \geq 0.22$) by dam's prepartum BW change or BCS. However, steers from GAIN and MAIN tended ($P = 0.06$) to have increased ADG in the feedlot. Twelfth-rib fat thickness, longissimus muscle area, and days on feed were not influenced ($P \geq 0.18$) by late gestation BW change or BCS. Calves from BCS 6 cows tended ($P = 0.10$) to have greater yield grades at harvest in the feedlot. Percentage of steers grading Choice or greater was increased ($P < 0.01$) in steers from LOSS cows and cows in BCS 4 during late gestation compared with other groups. These data suggest that modest nutrient restriction during late gestation can have a minimal effect on growth and performance of steer progeny from birth through the finishing phase.

Additional keywords: beef cattle, fetal programming, reproduction.

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Introduction

Spring-calving beef cows in the western United States graze low-quality dormant forage during late gestation. Due to the decreased forage quality and increased nutrient requirements, bodyweight (BW) loss may occur during late gestation, which is thought to have long-term effects on progeny growth and health.

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In a review, Funston *et al*. (2010) suggests that late gestation restriction likely has a negative effect on final development of organ systems and regulation of nutrient uptake by tissues important for growth and reproduction. Furthermore, improving nutritional status during gestation has been reported to increase adipose tissue deposition, tenderness, and growth of steers (Underwood *et al.* 2010).

However, cows that have been adapted and managed to reproduce in harsh, limited nutrient environments may have the ability to maintain normal fetal growth and development during periods of maternal nutrient restriction. Maternal undernutrition in gestating ewes adapted to nutrient-limited environments did not affect fetal plasma concentrations of glucose or fetal growth (Vonnahme *et al.* 2006) and were able to maintain fetal concentrations of amino acids (Jobgen *et al.* 2008). This implies that there is a mutual synchrony with the dam and fetus that may provide a natural adjustment against prepartum protein undernutrition when livestock are adapted to their environment (Martin *et al.* 1997). We hypothesised that modest nutrient restriction (that is normal to a management regime) during late gestation has minimal effects on progeny feedlot performance when a cow herd evolves through generational exposure and adapts with niche fitness for their limited-nutrient environment. Therefore, the objectives of this study were to use classification by BW change and body condition score (BCS) during late gestation on subsequent cow pregnancy rates, progeny steer feedlot performance, and health.

Materials and methods

All animal handling and experimental procedures were in accordance with guidelines set by the New Mexico State University Institutional Animal Care and Use Committee.

Cow performance

Over 7 years, 291 Angus and Angus × Hereford crossbred, spring-calving, cows (523 ± 3 kg at autumn weaning) between 3 and 8 years of age from the Corona Range and Livestock Research Centre (CRLRC), Corona, New Mexico were used to retrospectively determine the effects of BW change and BCS during late gestation on progeny steer feedlot performance. During the 7 years of the experiment, all cows between the age of 3 and 8 years from CRLRC that produced a steer calf were used for the study. No other criteria were utilised for selection of animals. Cows entering the study during the 7 years were progeny of cows managed in a similar scheme at the same location. The CRLRC is located in central New Mexico with an average elevation of 1900 m. Annual precipitation averages 401 mm, with ~70% of annual precipitation occurring from May to October. Forages at this study site were primarily blue grama (*Bouteloua gracilis*), threeawns (*Aristida* spp.), and common wolftail (*Lycurus phleoides*). Pastures contained ~355–674 kg/ha of standing forage and were stocked at a rate that was 50% less than the Natural Resources Conservation Service recommended rate. Therefore, forage availability was assumed not to limit cow productivity. Pastures used in the study ranged from 260 to 2023 ha.

Cows were weighed in October, December, and February in each year. BCS (1 = emaciated, 9 = obese; Wagner *et al.* 1988) were assigned at these periods to each cow by visual observation and palpation by two trained technicians. Cows were managed together in the same winter grazing environment each year. Their responses to diet quality, changing physiological state and winter weather were assessed by BW change and BCS. Cows were classified as 1 of 3 BW change groups: (1) cows that lost BW during late gestation (LOSS; mean –25 ± 2 kg); (2) cows that maintained BW during late gestation (MAIN; mean –1 ± 1 kg); or (3) cows that gained BW during late gestation (GAIN; mean 25 ± 2 kg). Cows were also classified to 1 of 3 BCS groups: BCS of 4 (mean BCS = 4.0 ± 0.02; range 4.0–4.5), 5 (mean BCS = 5.0 ± 0.02; range 5.0–5.5), or 6 (mean BCS = 6.0 ± 0.02; range 6.0–6.5).

Average calving date was 16 March. A 60-day breeding season was utilised in all years and was initiated in early or mid-May with all cows managed as a single herd. Cows were exposed to fertile bulls at a ratio of ~1 : 25. Initiation of breeding occurred on average 65 ± 2 days postpartum across all years. A 36% crude protein supplement was fed twice per week after calving at a rate of 908 g/(cow per day) for 55 ± 2 days after calving. At weaning, cows were diagnosed for pregnancy by rectal palpation.

Calf performance

All calves were preconditioned, conforming to Value Added Calf-45 management guidelines (Anonymous 2005). After preconditioning, steers (*n* = 291) were shipped to and fed at a commercial feedlot. The final BW during the preconditioning phase was used as the initial BW of the finishing phase.

Steers were received and treated as custom-fed commercial cattle at the feedlot in mid-November each year, and were managed according to the procedures in place at the feedlot. Steers received step-up diets for ~21 days before receiving a high concentrate finishing diet. Each year, experienced feedlot staff (individuals varied) diagnosed morbidity by subjective visual appraisal in compliance with the current feedlot policy. At receiving, all steers were administered a growth-promoting implant (Component ES, VetLife Inc., Overland Park, KS, USA) and preventive pharmaceuticals based on judgment of feedlot management. Steers were processed for a secondary application of growth implant (Component ES, VetLife Inc.) at 74–94 days. At this time in Years 1–3, an interim weight was recorded and steers were individually assigned to a marketing group using ultrasound technology for a common backfat thickness and computer software from the Cattle Performance Enhancement Co. (CPEC, Oakley, KS, USA). In Years 4–7, steers were visually appraised for a common backfat thickness by experienced feedlot management for a single marketing date to achieve optimum performance. Steers were harvested in a commercial abattoir (National Beef, Liberal, KS, USA) at which carcass data were collected on each animal. Hot carcass weight was recorded at slaughter and carcass traits were evaluated by an independent data collection service (Cattle Trail LLC, Johnson, KS, USA) following chilling.

Statistical analyses

Normality of data distribution and equality of variances of measurements were evaluated using PROC UNIVARIATE, the Levene test, and PROC GPLOT, respectively. The MIXED procedure (SAS Institute Inc., Cary, NC, USA) was used to test all main effects and all possible interactions. The model included fixed effects of BW change classification, BCS classification, year, and their interaction with cow as the experimental unit using the Kenward–Roger degrees of freedom method. Cow age was used as a blocking term. No significant late gestation BW change × BCS interactions or interactions with year were observed (P > 0.10). Therefore, only the main effects of BW change and BCS will be shown and discussed. Frequency and categorical data (i.e. pregnancy data, carcass quality grade and yield grade, and calf feedlot morbidity) were analysed as binomial proportions using the GLIMMIX procedure of SAS using the same model as described previously. For the frequency data, the ILINK option of the LSMEANS statement was used to determine least-squares means of the proportions.

Results

Cow bodyweight change effects

Initial (3 weeks after weaning) and final (2 weeks before first predicted calf birth) cow BW was different ($P \leq 0.01$; Table 1) among BW change classification groups, which resulted in differences (P = 0.01) in late gestation BW change. BCS was not different (P = 0.17) at the initiation of the study; however, the cows in the LOSS category had lowest BCS (P < 0.01) before calving. Although BCS before calving were decreased in LOSS cows, pregnancy rates were greater (P < 0.01; Table 1) in LOSS and MAIN cows relative to GAIN cows.

Calf BW at weaning was not influenced (P = 0.58; Table 2) by dam's late gestating BW change. After a 45-day preconditioning period, initial feedlot BW was not different (P = 0.46) for progeny of cows that gained, lost, or maintained BW during late gestation. Final feedlot BW of progeny was not influenced (P = 0.22) by dam's late gestation BW change. Calves from LOSS cows had a tendency (P = 0.06) for lower average daily gain in the feedlot relative to MAIN and GAIN progeny. Days on feed were not different (P = 0.24) for progeny from LOSS, MAIN, and GAIN cows.

Proportion of calves treated for sickness in the feedlot was not different (P = 0.49; Table 2) from cows that gained, lost, or maintained BW during late gestation. Furthermore, death loss in feedlot was not different (P = 0.57) due to BW change classification GAIN, LOSS, and MAIN cows.

Steer hot carcass weight and dressing percentage were not influenced ($P \geq 0.26$; Table 3) by dam's gestation BW change. Similarly, 12th-rib fat thickness, longissimus muscle (LM) area, and yield grades were unaffected ($P \geq 0.24$) by dam's late gestation BW change. However, marbling score had a tendency (P = 0.06) to increase with progeny from dams that lost BW during late gestation, which resulted in a greater percentage of calves from LOSS dams grading Choice or greater than calves from MAIN and GAIN dams (P < 0.01).

Table 1. Effects of late gestation bodyweight (BW) change on reproduction, BW, and body condition score (BCS) in cows grazing native dormant range

a,b,c, Means with different letters differ ($P \leq 0.05$)

Item	Late gestation BW change[A]			s.e.m.	P-value
	LOSS	MAIN	GAIN		
n =	106	96	89	–	–
		Cow BW (kg)			
Initial[B]	533a	527a	497b	7	<0.01
Final[C]	508a	526b	522ab	7	0.02
BW change	–25a	–1b	25c	2	0.01
		BSC			
Initial[B]	5.1	5.1	5.0	0.02	0.17
Final[C]	4.5a	4.9b	5.2c	0.08	<0.01
Pregnancy rate (%)	97a	94a	84b	2	<0.01

[A]Cows that lost BW during late gestation (LOSS; mean –25 ± 2 kg); (2) cows that maintained BW during late gestation (MAIN; mean 1 ± 1 kg); and (3) cows that gained BW during late gestation (GAIN; mean 25 ± 2 kg).
[B]October BW and BCS.
[C]February BW and BCS.

Table 2. Effects of dam bodyweight (BW) change during late gestation on calf performance from weaning through the finishing phase

Item	Late gestation BW change[A]			s.e.m.	P-value
	LOSS	MAIN	GAIN		
n =	106	96	89	–	–
Weaning BW (kg)	245	247	240	7	0.58
		Feedlot performance			
Initial BW (kg)	260	265	258	8	0.46
Final BW (kg)	490	504	493	13	0.22
Average daily gain (kg)	1.29	1.38	1.37	0.07	0.06
DOF[B]	180	177	174	5	0.24
% Treated for sickness	27	34	37	5	0.49
% Death loss	4	5	2	2	0.57

[A]Cows that lost BW during late gestation (LOSS; mean –26 ± 2 kg); (2) cows that maintained BW during late gestation (MAIN; mean 1 ± 1 kg); and (3) cows that gained BW during late gestation (GAIN; mean 25 ± 2 kg).
[B]Days on feed.

Table 3. Effects of dam bodyweight (BW) change during late gestation on carcass traits in steer progeny

a,b,c, Means with different letters differ ($P \leq 0.05$)

Item	Late gestation BW change[A]			s.e.m.	P-value
	LOSS	MAIN	GAIN		
Hot carcass weight (kg)	309	318	311	9	0.26
Dressing percentage[B]	63.10	63.06	63.08	0.08	0.91
Marbling score[C]	532	505	495	6	0.06
12th-rib fat (cm)	1.39	1.44	1.43	0.11	0.85
LM area (cm^2)	75.52	77.58	76.14	2.12	0.24
Yield grade	2.99	2.97	3.02	0.19	0.97
Choice or greater (%)	85a	63b	46c	3	<0.01
Select (%)	15a	37b	54c	4	<0.01

[A]Cows that lost BW during late gestation (LOSS; mean –26 ± 2 kg); (2) cows that maintained BW during late gestation (MAIN; mean 1 ± 1 kg); or (3) cows that gained BW during late gestation (GAIN; mean 25 ± 2 kg).
[B]Dressing percentage = hot carcass weight/final unshrunk BW.
[C]Marbling score: 500 = small^0.

Late gestation BCS effects

Initial and final BW were different ($P < 0.01$; Table 4) for cows in BCS 4, 5, and 6. However, BW change was similar ($P = 0.11$) among BCS groups. BCS were different among the BCS groups ($P \leq 0.01$) at the initiation and termination of the study. Pregnancy rates after a 60-day breeding season were not different ($P = 0.15$) for cows in a BCS 4, 5, and 6 during late gestation.

Calf weaning BW was not different ($P = 0.56$; Table 5) among cows in a BCS 4, 5, or 6 during late gestation. After a 45-day preconditioning period, initial and final feedlot BW were not influenced ($P = 0.38$) by dam's late gestation BCS, resulting in similar ($P = 0.45$) feedlot average daily gain. Percentage of progeny treated for sickness in the feedlot and death loss were similar ($P \geq 0.24$) for calves from dams with a BCS 4, 5, 6 during late gestation. Days on feed were not different ($P = 0.30$) for progeny from cows in a BCS 4, 5, or 6 during late gestation.

Hot carcass weight and dressing percentage were not influenced ($P \geq 0.46$; Table 6) by dam's late gestation BCS. Dam's late gestation BCS did not impact ($P > 0.18$) progeny's 12-rib fat thickness or LM area. However, progeny from cows in a BCS 6 during late gestation have a tendency for increased ($P = 0.10$, Table 6) calculated yield grade relative to progeny from cows in a BCS 4 and 5. Percentage of progeny grading Choice or greater was increased ($P < 0.01$) with dams in a BCS 4 during late gestation.

Discussion

Cow performance

Cow BW change during late gestation is reflection of the proportion of relative nutrient consumption compared with nutrient demands. During periods of low energy intake, mobilisation of maternal nutrient lipid reserves is needed to offset energy imbalances of gestation. Cows that lost or maintained BW during late gestation were heavier at initiation of the study, whereas the lightest cows at initiation of the study gained BW during late gestation. Range of BW change observed in this study were similar to Hough *et al*. (1990), which fed cows to either 100% National Research Council (NRC) or 57% NRC for energy and protein requirements during later gestation. In addition, BW change for MAIN and LOSS cows in this study were comparable with BW changes reported for cows fed either supplemental protein or no supplement reported by Stalker *et al*. (2006). In this study, overall pregnancy rates were greater in cows either losing or maintaining BW during late gestation compared with cows gaining BW. In contrast, Stalker *et al*. (2006) reported no difference in pregnancy rate between cows that lost 37 kg of BW (non-protein nitrogen supplemented) and cows that maintained BW (protein nitrogen supplemented) during late gestation. BW loss during late gestation may create opportunity for lower maintenance requirements and improved nutritive utilisation efficiency postpartum, which could enhance reproductive performance (Spitzer *et al.* 1995; Lalman *et al.* 2000; Ciccioli *et al.* 2003). Therefore, improved reproductive

Table 4. Effects of body condition score (BCS) during late gestation on reproduction, bodyweight (BW), and BCS in cows grazing native dormant range

a,b,c, Means with different letters differ ($P \leq 0.05$)

Item	BCS[A] 4	5	6	s.e.m.	*P*-value
n =	102	135	54	–	–
		Cow BW (kg)			
Initial[B]	494a	518b	545c	7	<0.01
Final[C]	496a	516b	543c	7	<0.01
BW change	2	–1	–2	2	0.11
		BCS			
Initial[B]	4.2a	5.0b	6.0c	0.02	<0.01
Final[C]	4.4a	4.8b	5.2c	0.07	<0.01
Pregnancy rate (%)	96	89	92	3	0.15

[A]Late gestation BCS of 4 (mean initial BCS = 4.2 ± 0.02; range 4.0–4.5), 5 (mean initial BCS = 5.1 ± 0.02; range 5.0–5.5), or 6 (mean initial BCS = 6.0 ± 0.02; range 6.0–6.5).
[B]October BW and BCS.
[C]February BW and BCS.

Table 5. Effects of body condition score (BCS) during late gestation on calf performance from weaning through the finishing phase

Item	BCS[A] 4	5	6	s.e.m.	*P*-value
Weaning bodyweight (BW; kg)	242	244	246	4	0.56
		Feedlot performance			
Initial BW (kg)	257	260	265	5	0.38
Final BW (kg)	494	491	501	9	0.51
Average daily gain (kg)	1.34	1.33	1.38	0.04	0.45
DOF[B]	178	175	179	5	0.30
% Treated for sickness	33	30	34	6	0.88
% Death loss	4	2	7	2	0.24

[A]Late gestation BCS of 4 (mean BCS = 4.2 ± 0.02; range 4.0–4.5), 5 (mean BCS = 5.1 ± 0.02; range 5.0–5.5), or 6 (mean BCS = 6.0 ± 0.02; range 6.0–6.5).
[B]Days on feed.

Table 6. Effects of body condition score (BCS) during late gestation on carcass traits in steer progeny

a,b,c, Means with different letters differ ($P \leq 0.05$)

Item	BCS[A] 4	5	6	s.e.m.	*P*-value
Hot carcass weight (kg)	311	310	317	6	0.46
Dressing percentage[B]	63.06	63.05	63.12	0.08	0.65
Marbling score[C]	515	512	510	11	0.89
12th-rib fat (cm)	1.39	1.37	1.49	0.07	0.28
LM area (cm^2)	75.57	77.44	76.24	1.32	0.18
Yield grade	2.95	2.88	3.15	0.12	0.10
Choice or greater (%)	77a	63b	52c	3	<0.01
Select (%)	23a	37b	48c	4	<0.01

[A]Late gestation BCS of 4 (mean BCS = 4.2 ± 0.02; range 4.0–4.5), 5 (mean BCS = 5.1 ± 0.02; range 5.0–5.5), or 6 (mean BCS = 6.0 ± 0.02; range 6.0–6.5).
[B]Dressing percentage = hot carcass weight/final unshrunk BW.
[C]Marbling score: 500 = small^0.

performance may be attributed to decreased nutrient requirements in LOSS cows and an overall increase in nutrient utilisation.

Calf BW at weaning and initial feedlot BW was not influenced by dam's gestational BW change. In contrast, Houghton *et al*. (1990) reported that calves from cows that maintained and gained BW during late gestation had greater BW at 105 days postpartum than calves born to cows that lost BW. Corah *et al*. (1975) also found that nutrient restriction resulted in a decrease in calf weaning BW. Although steers from cows that lost BW during late gestation tended to have the lowest ADG in the feedlot, final feedlot BW was not influenced by dam's gestational BW change.

Morbidity associated with bovine respiratory disease in fed cattle is near 20% of the total cattle on feed (Faber *et al.* 1999). Mulliniks *et al*. (2012) and Larson *et al*. (2009) indicate that late gestation nutrition may influence the number of calves treated for bovine respiratory disease in the feedlot. Blecha *et al*. (1981) suggested that calves may experience reduced passive immunity when pre-calving nutrient availability is low. Passive immunity transfer at calving has been speculated to have long-term effects on calf profitability from weaning through the finishing phase. Wittum and Perino (1995) reported that calves classified as having lower plasma protein (<4.8 g/dL) concentration at 24 h postpartum had a greater risk of morbidity and respiratory tract morbidity whereas in the feedlot than calves with higher plasma protein at 24 h postpartum. However, level of nutrient restriction in this study did not cause increased sickness or death in progeny through the feedlot phase. Vonnahme *et al*. (2006) demonstrated that ewes adapted to limited nutrient availability and climatic/ environmental conditions that increase energy requirements were able to alter physiological responses during maternal nutrient restriction, which sustained normal growth to their offspring.

Maternal nutrition during gestation has been previously shown to affect fetal skeletal muscle and adipose tissue growth and development (Du *et al.* 2010). However, in this study, steer hot carcass weight, 12th-rib fat thickness, LM area, and yield grades were unaffected by dam's late gestation BW change. However, marbling score tended to be greater with calves from dams that lost BW, resulting in increased percentage of carcasses grading Choice or greater. In contrast, Underwood *et al*. (2010) reported that cows grazing on improved forage pastures during late gestation produced progeny with similar marbling scores in subsequent steer progeny relative to cows grazing dormant native range of lower quality. The fetal stage may be the most efficient time to affect the amount of marbling in offspring, due to adipogenesis starting around mid gestation and increasing during late gestation (Du *et al*. 2010). During this period of gestation, the placenta has a high selectivity for certain fatty acids and is largely dependent on maternal circulation of fatty acids (Haggarty 2002). Therefore, BW loss during late gestation may increase fatty acids supply to the fetus thereby increasing adipogenesis and subsequent potential for marbling.

Late gestation BCS effects

Pregnancy rates after a 60-day breeding season were not influenced by late gestation BCS. In a similar herd, Mulliniks *et al*. (2012) reported that BCS did not influence resumption to oestrous or pregnancy rates in young cows grazing native range. Looper *et al*. (2003) reported that beef cows in thin body condition (BCS 4) had an extended postpartum interval compared with cows in a moderate body condition (BCS 5). These results of the present study may be partially explained by the long-term management of the cows. First, the cows used in this study were offspring of cows that have been managed in a low-input production system for multiple generations. In addition, variation of BCS among cows in the present study was a response to the collective effects of management, genetics and environment and not due to nutritional manipulation to achieve certain calving BCS. Overall, extensive and strategic cow herd management that is implemented over multiple generations may create lower BCS thresholds for reproductive success.

Calf BW at weaning and initial and final feedlot BW were not influenced by late gestation BCS of dams. In addition, dam's late gestational BCS did not impact progeny's marbling score, fat thickness, or LM area. However, calves from cows in a BCS 6 did have a tendency for increased yield grade. Furthermore, percentage of progeny grading Choice or greater was increased with dams in a BCS 4 during late gestation. In contrast, Bohnert *et al*. (2010) reported no difference in percentage of progeny grading Choice from dams in a BCS 4 or 6 during late gestation. However, fatness in humans has been shown to modify the physiology of gestation. For example, placentas of obese women have above normal levels of inflammation and oxidative stress (Roberts *et al.* 2009, 2011), which may alter uptake and metabolism of fatty acids. Furthermore, male fetuses born to obese mothers have been associated with lower oleic acid uptake (Brass *et al.* 2013). Therefore, it is possible that BCS during late gestation may play a role in placental fatty acid uptake, resulting in differences in quality grade.

Conclusion

During late gestation, BW change or BCS had no effect on calf growth from birth through the feedlot finishing phase. It is likely that the severity of environmental stresses or nutrient restriction during gestation might play a role in calf performance when the range of BW change is greater than reported in this study. However, this study does reveal that the proportion of calves born from dams losing BW during late gestation that graded Choice or greater were increased relative to cows that maintained or gained BW. In addition, cows that lost or maintained late gestation BW had increased pregnancy rate the following year. Therefore, in a beef cow herd that has a history of minimal nutritional management and allowing for late gestation BW loss, minimal to no effects on progeny or dam productivity would be expected, but increased progeny carcass quality may occur.

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