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Aline G. da Silva
University of Nebraska-Lincoln

Jacqueline A. Musgrave
University of Nebraska-Lincoln, jmusgrave1@unl.edu

John Nollette Nollette
University of Nebraska-Lincoln, john.nollette@unl.edu

Andy Applegarth
University of Nebraska-Lincoln, andy.applegarth@unl.edu

Rick N. Funston
University of Nebraska-Lincoln, rfunston2@unl.edu

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Summary

Records collected from 1997 to 2014 were analyzed to evaluate the effects of dam age on offspring productivity. Steer calves born from young mothers (2 and 3 yr old dams) had lighter carcasses with more carcasses grading Choice and upper 2/3 Choice. The calving performance and reproductive performance in the second breeding season for heifer calves born from first calving dams were the lowest compared with heifers born from multiparous dams. A quadratic effect of dam age on offspring performance was observed; as dam age increased, offspring performance increased, until dam age reached 7 to 8 yr and then offspring performance decreased.

Introduction

It is well accepted first calving heifers and old cows are less productive than middle age cows. Beef breed associations and the Beef Improvement Federation Guidelines (2010) recommend adjusting the birth and weaning weight of calves contingent upon dam age. However, most of the studies limit their comparisons to primiparous *vs*. multiparous females and researchers concentrate on dam performance or offspring performance only in the pre-weaning phase. Few studies have evaluated the effects of dam age on offspring productivity later in their lives, especially for heifer calves. This study evaluated the effects of dam age at calving on male calf performance from birth to slaughter and female calf productivity from birth through her second breeding season.

Procedure

Data was collected from a composite Red Angus × Simmental herd from the Gudmundsen Sandhills Laboratory (GSL), Whitman, NE from 1997 to 2014 for heifer calves (n = 1,524) and from 2003 to 2014 for steer calves (n = 1,195).

Breeding protocol

From 1997 to 2002, cows and heifers were exposed to a natural service breeding season for 60 d at a bull to female ratio of 1:25. From 2003 to 2014, females were exposed to bulls for 45 d at a bull to female ratio of 1:25 and a single injection of $PGF_{2\alpha}$ was administered i.m. 108 h after placement with bulls. Pregnancy diagnosis was performed via transrectal ultrasonography approximately 45 d after the breeding season.

Culling and replacement

Cows and heifers were culled when they failed to become pregnant; cows were also culled for advanced age or health issues. First calving heifers replaced culled cows. All replacement heifers were born and developed at GSL.

Offspring performance

Heifer calves

Performance parameters evaluated included: birth weight, adjusted 205 d weaning weight, pre-breeding BW, BW and BCS at pregnancy diagnosis, BW and BCS at calving, and BW and BCS at weaning of their first calf. Reproductive performance parameters include pubertal status and pregnancy rate for their first and second breeding seasons. Pubertal status was determined by progesterone concentration measured in 2 blood samples taken 10 d apart prior to the first breeding season.

Steer calves

Performance parameters evaluated included: birth weight, adjusted 205 d weaning weight, BW at slaughter, HCW, ADG from birth to weaning, and ADG from weaning to slaughter. At slaughter, marbling score, fat thickness, ribeye area, and yield grade were measured.

Statistical analysis

Data were analyzed using PROC GLIMMIX of SAS 9.4 (SAS Inst., Inc., Cary, NC). The model includes the fixed effect of dam age, and random effects of yr and treatment applied to dam and offspring due to other experiments occurring simultaneously to this study. Means were adjusted using Julian birth date as a covariate. Orthogonal contrasts were used to compare primiparous and multiparous females and also to evaluate the linear and quadratic effects of dam age on offspring productivity.

Results

The results for the heifer calves are presented in Table 1. Compared with multiparous, primiparous-born heifer calves had lower birth BW, adjusted 205 d weaning weight, pre-breeding BW and pregnancy diagnosis BW ($P < 0.05$). There was a linear and quadratic relationship ($P < 0.05$) of dam age on birth BW and adjusted 205 d weaning weight. The same pattern is observed for steer calf birth BW and adjusted 205 d weaning weight ($P < 0.05$, Table 2). Final BW and HCW were greater for middle age steer calves (Table 2) (primiparous vs. multiparous contrast and quadratic effect, $P < 0.05$). As dam age increases, offspring BW at different phases also increases until the dam is 7 to 8 yr old and then decreases.

A lower percentage of heifers born from primiparous dams were pubertal prior to the breeding season compared with heifers born from multiparous dams ($P < 0.01$). There was a linear tendency ($P = 0.06$) of dam age affecting the percentage of heifers pubertal prior to the breeding season, heifers born from young dams tended to have a lower cycling rate compared with heifers from older dams, but no difference was observed on pregnancy rates in the first breeding season ($P > 0.10$).

Table 1. Effect of dam age at calving on heifer performance

Item	Dam Age									SEM	Contrast		
	2	3	4	5	6	7	8	9	10		Primiparous *vs* Multiparous	Linear	Quadratic
n	308	273	201	192	163	133	91	62	59				
Heifer Performance													
Birth BW, lb	70	76	78	78	80	80	80	78	80	2	< .01	0.06	0.05
Adj. 205d Weaning BW, lb	371	425	446	452	457	459	460	448	459	19	< .01	< .01	< .01
Birth to Weaning ADG, lb	1.44	1.69	1.79	1.82	1.84	1.85	1.86	1.80	1.85	0.09	< .01	< .01	< .01
Pre-breeding BW, lb	636	648	661	662	669	665	671	667	670	15	< .01	0.04	0.18
Weaning to Pre-breeding ADG, lb	1.12	0.92	0.87	0.85	0.85	0.83	0.84	0.83	0.82	0.07	< .01	< .01	0.13
Overall Birth to Pre-breeding ADG, lb	1.33	1.35	1.37	1.38	1.39	1.38	1.39	1.39	1.39	0.04	< .01	0.06	0.23
Heifers Pubertal, %	56	69	76	74	75	83	74	68	83	8	< .01	0.06	0.72
Pregnancy Check BW, lb	799	810	821	822	825	820	824	820	821	17	< .01	0.33	0.41
Pregnancy Check BCS	5.76	5.77	5.80	5.81	5.79	5.78	5.80	5.75	5.78	0.08	0.56	0.86	0.76
Pre-breeding to Pregnancy Check ADG, lb	1.85	1.84	1.83	1.81	1.80	1.75	1.73	1.74	1.75	0.13	0.09	0.20	0.27
Pregnancy Rate, %	86	86	86	90	84	87	87	89	77	8	0.88	0.22	0.25
Fist Calving Heifer Performance													
Calved in the first 21d, %	73	72	76	80	76	82	83	76	64	8	0.50	0.32	< .01
Assisted, %	27	24	31	24	26	24	30	31	19	6	0.78	0.52	0.28
Post-calving BW, lb	926	949	948	950	960	954	969	957	950	20	< .01	0.93	0.24
Post-Calving BCS	5.35	5.28	5.26	5.28	5.25	5.33	5.22	5.26	5.30	0.08	0.04	0.85	0.74
1st Calf Wean Cow BW, lb	914	922	926	928	946	946	948	942	935	15	0.16	0.34	0.06
1st Calf Wean Cow BCS	5.06	5.16	5.07	5.13	5.15	5.16	5.16	5.17	5.12	0.09	0.04	0.85	0.74
2nd Breeding Season Performance													
2nd Pregnancy Rate, %	58	81	85	78	82	90	83	94	87	10	0.01	0.61	0.69

Heifers born from cows 4 to 9 yr old had more calves born in the first 21 d of the calving season (quadratic effect, $P < 0.05$). Heifer calves born to multiparous cows had greater BW and BCS at calving and greater BCS when their first calf was weaned ($P < 0.05$).

Although there was no difference in the first breeding season, heifers born from 2 yr old dams had lower pregnancy rates in the second breeding season ($P = 0.01$). The improved calving performance of heifers born from multiparous dams, especially in terms of BCS at calving and weaning may have contributed to greater pregnancy rates in the second breeding season compared with heifers born from primiparous dams.

Male calves born from primiparous dams had greater marbling scores, lower fat thickness, lower percentage of carcasses grading Select, a higher percentage of carcasses grading Choice and upper 2/3 Choice, and a lower percentage of carcasses with yield grade 3 ($P < 0.05$). There was a linear effect of dam age on the percentage of carcasses grading Standard ($P < 0.05$), as dam age increased more carcasses graded Standard.

There was a quadratic effect of dam age on ribeye area and yield grade 2 ($P < 0.05$), and a quadratic tendency ($P = 0.06$) on the percentage of carcasses grading Select. As dam age increased, steers had greater ribeye area and heavier HCW until dam age was 7 to 8 yr old, and then offspring performance decreased. As a consequence, steers born to young dams produced lighter, less muscled, and more marbled carcasses; which might explain the better carcass quality grades for steers born from young mothers.

Overall effects of dam age on offspring performance are likely affected by genetics and environment. The environmental effects in turn can be divided into 2 phases: in utero and pre-weaning phase.

Epigenetic modifications caused by adverse uterine environment can affect fetal growth and subsequent calf performance, even later in life (*Annual Review of Animal Biosciences*, 1:339–363). During pregnancy,

Table 2. Effect of dam age at calving on steer performance

Item	Dam Age									SEM	Contrast		
	2	3	4	5	6	7	8	9	10		Primiparous *vs* Multiparous	Linear	Quadratic
n	268	220	217	138	130	81	49	41	41				
Steer Performance													
Birth BW, lb	75	81	82	83	84	87	87	89	89	2	< .01	< .01	0.03
Adj. 205d Weaning BW, lb	476	510	526	530	543	545	552	565	558	15	< .01	< .01	0.01
Final BW, lb	1,255	1,300	1,320	1,317	1,343	1,351	1,340	1,367	1,329	20	< .01	0.12	0.02
Over Weight, %	1	3	5	4	9	11	5	9	8	5	< .01	0.10	0.40
Pre Weaning ADG, lb	1.96	2.10	2.16	2.18	2.24	2.24	2.27	2.32	2.29	0.07	< .01	< .01	0.02
Post Weaning ADG, lb	3.42	3.38	3.41	3.40	3.40	3.45	3.42	3.51	3.38	0.11	0.97	0.98	0.31
Carcass traits													
HCW, lb	793	821	834	830	845	849	845	863	838	13	< .01	0.15	0.04
Marbling Score	548	541	544	542	526	513	509	505	516	18	< .01	0.09	0.10
Fat Thickness, inches	0.502	0.534	0.575	0.550	0.551	0.529	0.527	0.512	0.520	0.030	0.01	0.55	0.96
REA, inches^2	13.7	13.6	13.6	13.5	13.7	13.9	14.2	14.3	13.7	0.3	0.19	0.82	0.01
USDA Quality Grade													
Standard, %	3	3	3	5	6	3	2	5	9	5	0.48	0.04	0.26
Select, %	22	25	28	29	26	38	38	39	29	7	0.01	0.57	0.06
Choice, %	70	65	67	65	61	57	60	56	61	8	0.02	0.62	0.47
Upper 2/3 Choice, %	23	25	24	29	23	9	15	7	12	5	0.03	0.09	0.18
Prime, %	1	1	1	1	2	0	0	0	0	1	0.98	0.99	0.99
USDA Yield Grade													
YG 1, %	7	6	4	10	5	6	4	2	2	2	0.18	0.29	0.74
YG 2, %	49	45	43	40	45	45	56	43	29	7	0.17	0.06	0.03
YG 3, %	37	39	44	42	45	40	39	56	60	8	0.03	0.01	0.12
YG 4 and 5, %	7	10	8	7	5	9	2	0	10	5	0.97	0.96	0.14

young dams need energy and nutrients not only for fetal development, but also for their own maintenance and growth. In this high nutritional requirement scenario, it is more likely nutritional imbalances affect nutrient and energy availability for the fetus and may explain the differences in offspring performance from a fetal programing stand point.

The pre-weaning environment effect is represented basically by milk supply for the calf. Young cows (2 and 3 yr old) do not produce as much milk as middle age cows (*Journal of Animal Science*, 81:1693–1699), this might contribute to the differences in offspring performance, especially from birth to weaning.

It is hypothesized improved genetics in younger dams would result in increased performance of their offspring. However, if the dam does not provide an adequate uterine environment and/or enough milk, their calf cannot fully express their genetic potential.

The data suggest producers should select heifers born from cows 4 to 8 yr old as replacements. Heifers born from dams 3 yr old and younger are unable to express their genetics for growth and have an increased chance of failure in the first calving season and second breeding season, increasing their likelihood to be removed from the herd. Heifer progeny from dams older than 8 yr also exhibited decreased performance.

Aline G. da Silva, graduate student

Jacqueline A. Musgrave, research technician, Gudmundsen Sandhills Laboratory, Whitman

John Nollette, research technician, Gudmundsen Sandhills Laboratory, Whitman

Andy Applegarth, operations manager, Gudmundsen Sandhills Laboratory, Whitman

Rick N. Funston, professor, University of Nebraska–Lincoln West Central Research and Extension Center, North Platte.