animal - open space 3 (2024) 100072

Contents lists available at ScienceDirect

animal - open space

Research article

Age at first gestation in bovine influences female progeny post-weaning growth and reproductive development

S. López-Valiente [a,*], A.M. Rodriguez [a], N.M. Long [b], S. Maresca [a]

[a] Cuenca del Salado Experimental Station, Instituto Nacional de Tecnología Agropecuaria, Rauch, BA, 7203, Argentina
[b] Department of Animal and Veterinary Sciences, Clemson University, Clemson 29634, USA

ARTICLE INFO

Article history:
Received 23 January 2024
Revised 27 May 2024
Accepted 3 June 2024

Handling editor: Javier Álvarez-Rodríguez

Keywords:
Cow
Heifer
Offspring
Performance
Puberty

ABSTRACT

This study investigated the impact of the age at which heifers conceive for the first time on the growth and reproductive development of their female offspring. A total of seven heifers pregnant at 15 months of age (**15M**), nine heifers pregnant at 27 months of age (**27M**) and seven multiparous pregnant cows (**Adult**) were used in the present trial. All dams were pregnant by AI from a single sire and managed in a single group during gestation, lactation and rearing stages. After weaning heifer calves were stocked on natural pastures. Progeny of heifers that gestated for the first time at different ages did not present differences in growth; however, progeny of 15 and 27M dams had reduced BW, longissimus muscle area and 12th fat thickness compared to progeny of adult dams ($P < 0.05$). Diameter of the largest follicle was greater in progeny born to Adult compared to progeny born to 15 and 27M ($P = 0.04$). Reproductive tract score (**RTS**) in heifers born to Adult at 399 days of age was greater compared to heifers born to 27M, and this category presented greater development than heifers born to 15M ($P = 0.02$). At 435 days of age, the heifers born to Adult had a greater percentage defined as pubertal compared to the progeny of 15 and 27M ($P = 0.04$). At 495 days of age, the weight of uterus, ovaries and corpora lutea were not affected by the age of dams at calving ($P > 0.25$). These data indicated that the age at which heifers received their first service affects female offspring growth RTS at early ages, but it does not have any impact in organ development after diet with a high energy level.

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Implications

Many studies have focused on comparing the performance of beef heifers and multiparous dams' offspring, but few have explored how the age at first gestation impacts female progeny development and reproductive performance. This research demonstrates that the age at which heifers become pregnant can indeed influence their female progeny's reproductive development. The findings suggest that age at first conception has a notable impact, with adverse effects more pronounced in offspring born to heifers at 15 months. Therefore, selecting replacement heifers born at 27 months is more favorable, as they exhibit larger follicle diameters and better reproductive tract scores at younger ages compared to those born at 15 months. Nevertheless, using heifers born to adult cows remains the most recommended choice due to their greater development and precocity, even compared to those born at 15 or 27 months.

Specification table

Subject	Livestock Farming Systems
Type of data	Table and Figure
How data were acquired	The weights were through scales. Ultrasounds through Aquila pro, Esaote Europe B.V. The IGF1 concentration was quantified in one assay via radioimmunoassay.

(*continued on next page*)

* Corresponding author.
E-mail address: lopez.valiente@inta.gob.ar (S. López-Valiente).

https://doi.org/10.1016/j.anopes.2024.100072
2772-6940/

Data format	Raw data in XLSX format. Parameters for data collection.
Parameters for data collection	Data were collected under experimental beef operation in Experimental Farm from INTA.
Description of data collection	Heifers of 15 and 27 months of age (never previously mated), and multiparous Angus cows were inseminated and conceived to a single Angus sire in this study. The animals used in the present work are the entire female progeny since the objective was to evaluate the age of the mother in the reproductive growth and development of the females. All female progenies were weighed from birth to slaughter (435d). Ultrasounds and IGF 1 concentration were performed from rearing to slaughter, where the development and weight of the reproductive offspring were evaluated. The suggested changes for the resubmit will be made.
Data source location	Fill in the information available, and delete from this list as appropriate: Institution: National Institute of Agricultural Technology City/Town/Region: Las Armas, Buenos Aires. Country: Argentina Latitude and longitude (and GPS coordinates, if possible) for collected samples/data: 37°05′08.8″S 57°52′35.3″W
Data accessibility	Repository name: Mendeley Data Repository Data identification number: Lopez Valiente, Sebastian (2023), “Metadata Age at breeding-female progeny”, Mendeley Data, V1, https://doi.org/10.17632/wrgg8chnmv.1 https://data.mendeley.com/datasets/wrgg8chnmv/1
Related research article	López Valiente, S.; Rodriguez, A.M.; Long, N.M.; Quintans, G.; Miccoli, F.E.; Lacau-Mengido, I.M.; Maresca, S. Age at First Gestation in Beef Heifers Affects Fetal and Postnatal Growth, Glucose Metabolism and IGF1 Concentration. Animals 2021, Nov 27;11 (12):3393. https://doi.org/10.3390/ani11123393.

Introduction

The intensive management of cow-calf production has led to serving heifers at 15 months of age, likewise, previous research by (Nuñez-Dominguez et al., 1991) has shown that maximal reproductive and economic efficiency in beef cows is achieved when they produce offspring annually, starting with their first calf at 2 years of age. However, it has not been evaluated whether this technique can have consequences in the offspring compared to the progeny of heifers that gestated for the first time at 27 months of age. Early breeding of heifers can result in competition for nutrients among fetus, placenta, and still-growing mother, especially in environments where nutrient may be limited. Several studies have evaluated how the age of dams at first gestation affects the reproductive development of heifer offspring. This can potentially lead to daughters having smaller ovaries and greater concentrations of FSH (Petraitiene et al., 2020) or fewer antral follicles detectable by ultrasonography at an early age compared to heifers from multiparous cows (Akbarinejad et al., 2018). Based on the consulted literature, it can be concluded that replacement females from multiparous mothers have greater fertility and longer lifespans than those from primiparous dams. However, no evaluations were made between different ages of primiparous dams. There is a gap in knowledge regarding how different ages of heifers affect the development of the reproductive organs during the period after weaning and performance of subsequent generations. Therefore, it is important to clearly identify whether there are differences in the development of ovarian, uterus and the corpora lutea (**CL**) between heifers born to primiparous young dams at different ages and those born to multiparous dams.

Material and methods

Animals and sample collection

The experiment was conducted at the Experimental Station of Cuenca del Salado INTA (Buenos Aires, Argentina). Management of cows has been previously published (López Valiente et al., 2021); thus, only a brief description is presented here. Heifers of 15 and 27 months of age (never previously mated) and multiparous Angus cows were inseminated and conceived to a single Angus sire in this study. Pregnant dams were identified by transrectal ultrasound (Aquila pro, Esaote Europe B.V. Maastricht, NL; 5-MHz probe) 30 d after AI and a total of seven dams of 15 months of age, nine dams of 27 months of age and seven multiparous cows that produced heifer calves were used in the present experiment. During gestation, heifer and cow dams (average age = 5.6 ± 1.1 years old, range = 4–7 years old) from the three age groups were managed in a single group on oat pasture (62.8% in vitro DM digestibility (**IVDMD**); 15.9% CP). After parturition, all dams and their calves were managed in a single group on improved pastures (51.0% IVDMD; 10.7% CP), until weaning at 236 ± 10 days of age.

After weaning, female progeny born to dams from the three groups grazed annual ryegrass (63.4% total digestible nutrients (**TDN**); 14.3% CP) throughout the rearing phase. All these heifers were weighted at weaning (236 days of age), day 254, and every 33 d (±3d) with 16 h fasting and no access to water until the day 435 of age. Ultrasound measurements of the fat thickness and longissimus muscle area were taken between the 12th and 13th rib on the heifer’s right side, from day 304 until day 435 of age every 33 d (±3 d), using an Aquila pro, Esaote Europe B.V. Maastricht, NL; 3.5-MHz probe. Reproductive tract development was evaluated at 399 and 435 days of age using transrectal ultrasound (5.0-MHz transducer; Aquila System; Pie Medical Equipment B.V., Maastricht, Netherlands) to measure the diameter of the largest follicle and estimate the ovarian structures and reproductive tract score (Holm et al., 2009). Heifers with no structures on their ovaries (Reproductive tract score; **RTS** = 1), follicles < 8 mm in diameter (RTS = 2) or follicles 8–10 mm in diameter (RTS = 3) were classified as prepubertal. Heifers with follicles > 10 mm in diameter (RTS = 4) or corpora luteal (RTS = 5) were classified as pubertal.

At 399 days of age, all heifers received an ad-libitum diet for 96 days composed by 80% whole corn, 10% fescue hay and 10% protein supplement (88.4% DM, 13.1% CP, 75.1% TDN). After 24 h without feed, heifers were transported 95 km to a commercial slaughterhouse, where they were allowed free access to fresh water before harvest. Heifers were synchronized for estrus using 1 mg of oestradiol benzoate (Benzoate de oestradiol, Syntex) and controlled internal drug-releasing device (Cronipres, Biogenesis-Bago, Buenos Aires, Argentina) for 7 d, and upon removal of the device,1 mg of oestradiol benzoate (Benzoate de oestradiol, Syntex) and 2 mL of D-Cloprostenol (Enzaprost DC, Biogenesis-Bago, Buenos Aires, Argentina) were administrated intramuscularly 14 d before slaughter to synchronize their ovarian luteal cycles to allow comparisons of corpora luteal size. At harvest, all heifers had a corpora lutea present. All samples were collected within 20 min immediately after stunning. Uterus were removed from heifers and placed in ice until weighed. The ovaries were meticulously excised at their junction with the ovarian ligament, ensuring proximity to the ovarian tissue following the removal of the fimbria. Subsequently, the length of each ovary was measured along the incision from the ovarian ligament, while the width was determined as the maximum line perpendicular to this length. Corpora luteal were removed from ovaries, measured, and weighed.

Blood collection and assays

Blood samples were collected at weaning and from day 236 until day 435 every 33 d (±3 d) after a 16 h fasting and no access to water. After collecting the blood samples, they were placed on ice for 3 h, centrifuged (2 500 g for 15 min) for serum collection and stored at −20 °C until laboratory analysis was performed. Serum IGF-1 concentrations were quantified in one assay via radioimmunoassay after acid ethanol extraction using IGF-1 antibody (UB2-495) of the National Institute of Diabetes and Digestive and Kidney Diseases. Intra−assay CV was 7.4%, and the minimum detectable concentration was 2.2 ng/ml.

Statistical analysis

Animal measurements were analyzed using an individual dam or subsequent heifer calf as the experimental unit. All measurements of BW of heifers after weaning, carcass ultrasound, and IGF-1 concentration were analyzed using a completely randomized repeated measures model by ANOVA using the MIXED procedure of SAS (version 9.4, SAS Inst., Inc., Cary, NC, USA). Age of dam and sampling time were included in the model as fixed effects and animal as a random effect. The attainment of puberty was analyzed using the GENMOD procedure of SAS. BW and body condition score of the dams of female progeny, BW of progeny at birth, weaning, daily live weight gains and reproductive organs characteristics, were analyzed using the Proc GLM procedures of SAS (version 9.4, SAS Inst., Inc., Cary, NC, USA). Data are presented as least squares means and MSE, and differences are considered significant at $P \leq 0.05$, with a tendency at $0.05 < P \leq 0.10$.

Results

The effect of the age of dams at pregnancy on dams BW and body condition score (**BCS**) performance and their subsequent female offspring BW until weaning is shown in Table 1. There were differences in the BW of dams, with 15M dams exhibiting variance compared to 27M dams, and a reduction observed in both heifer groups relative to Adult dams at the commencement of the experiment ($P < 0.001$), at calving ($P < 0.001$), and at weaning ($P < 0.001$). The BCS demonstrated a significant difference at calving ($P = 0.01$) for 15M in comparison to adult dams. However, at weaning, BCS was notably lower in 15M dams compared to Adult dams, while 27M dams displayed an intermediate BCS ($P = 0.05$). The BW of the calves at birth and weaning, and preweaning daily gain decreased ($P = 0.06$, $P < 0.0001$, and $P = 0.003$, respectively) when the age at first calving was younger. Milk yield per day was 28.2% lower in primiparous dams compared to Adult dams ($P = 0.03$, López Valiente et al., 2021). There were no differences in post-weaning weight gain ($P = 0.71$) between heifers of different ages of dams, but the weight at 435 days was greater in heifers from adult dams compared to heifers from 15 and 27M dams ($P = 0.004$).

Age of dam had an effect on BW of female progeny from weaning to 453 days of life (Fig. 1A). Heifers from Adult had greater BW than heifers from 15 and 27M (273.6 ± 20.6, 237.8 ± 14.1, and 248.7 ± 14.4 kg, respectively; $P = 0.006$, Fig. 1A), their BW at 435 days were 306.7 ± 20.6, 313.8 ± 14.1, and 340.9 ± 14.4 kg respectively. Longissimus muscle area of heifers born to 15 and 27M dams had a 23.1 and 14.4% reduction (30.9 ± 2.7 and 34.4

Table 1
Effect of age at first gestation on cow BW and Body Condition Score (BCS) evolution and BW of female progeny until weaning.

Item	Age of dam 15M	27M	Adult	SEM	*P*-Value
BW, kg					
Initial	323^{a}	394^{b}	458^{c}	13.7	<0.0001
Change during gestation	18^{a}	27 ^{a}	59^{b}	10.1	0.02
At calving	340^{a}	421^{b}	517^{c}	9.3	<0.0001
Change during lactation	−19^{x}	−36^{xy}	−49^{y}	11.5	0.09
At weaning	321^{a}	385^{b}	468^{c}	9.6	<0.0001
BCS					
Initial	5.2	5.6	5.4	0.3	0.43
Change during gestation	0.1	−0.1	−0.3	0.5	0.48
At Calving	5.3^{a}	5.5^{ab}	5.1^{b}	0.1	0.01
Change during lactation	−1.3^{a}	−1.3^{a}	-0.7^{b}	0.6	0.05
At weaning	4.0^{a}	4.2^{ab}	4.4^{b}	0.1	0.05
BW female progeny					
At birth, kg	26.8^{x}	27.8^{y}	29.8^{z}	1.3	0.06
ADG, preweaning (g/d)	508.9^{a}	642.7^{b}	734.3^{c}	33.2	0.003
At weaning, kg	146.9^{a}	179.5^{b}	203.1^{c}	6.8	<0.0001
ADG post-weaning (g/d)	608.0	496.5	608.8	40.0	0.71
At 435 d, kg	267.9^{a}	278.3^{a}	324.1^{b}	9.9	0.004

Data presented as LSM ± SEM.
Body condition score (BCS) scale = 1–9 (Wagner et al., 1988).
[a,b,c] Row means that do not have a common superscript differ, $P < 0.05$.
[x,y,z] Row means that do not have a common superscript differ, $P < 0.10$.
Abbreviations: 15M = heifers were AI at 15 months of age; 27M = heifers were AI at 27 months of age; Adult = multiparous cows; ADG = average daily gain.

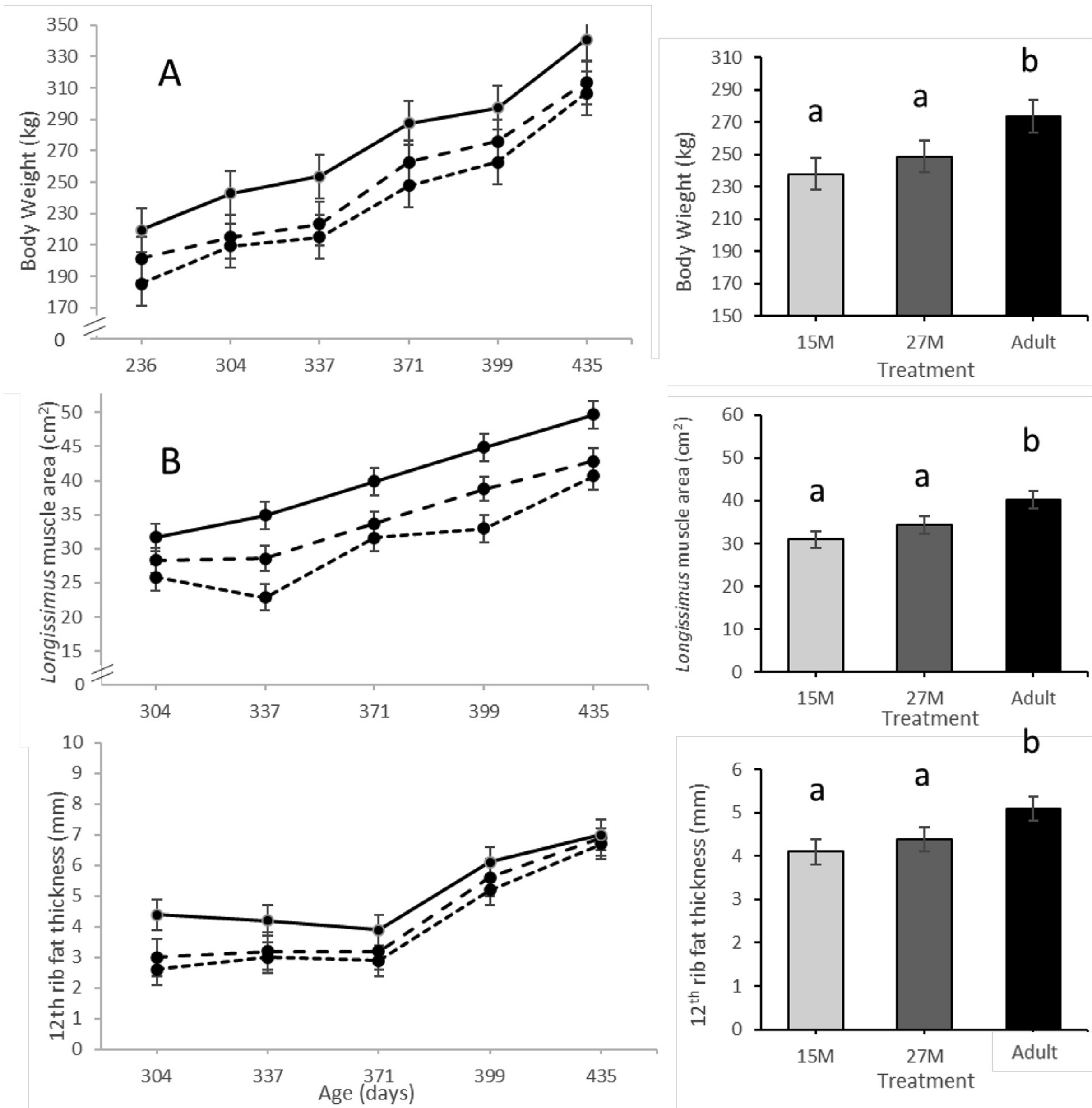

Fig. 1. BW (A), of female progeny born to heifers pregnant at 15 months of age (15M), 27 months of age (27M) and multiparous cows (Adult) from weaning until 435 days of age. Longissimus muscle area (B), and fat thickness (C) of female progeny born to heifers pregnant at 15 months of age (15M), 27 months (27M) and multiparous cows (Adult) from 304 days of age until 435 days of age. Values are means ± SEM. For BW: Age of dams, $P = 0.006$; time, $P < 0.0001$; age of dams × time, $P = 0.83$. For Longissimus muscle area, Age of dams, $P = 0.006$; time, $P < 0.0001$; age of dams × time, $P = 0.45$. For back fat thickness, Age of dams, $P = 0.02$; time, $P < 0.05$; age of dams × time, $P = 0.24$.

± 2.0 cm^2; respectively; Fig. 1B) compared to heifers born to adult dams (40.2 ± 2.1 cm^2; $P = 0.006$). Fat thickness at the 12th rib was reduced in progeny of primiparous dams (15 and 27M) compared to adult dams (4.1, 4.4 and 5.1 ± 0.3 mm, respectively; $P = 0.02$; Fig. 1C). Monthly serum IGF-1 concentration was not affected by age of dam from weaning to 435 days of age ($P = 0.20$, Fig. 2). There was no age of dam × time interaction for any variables ($P > 0.10$).

Data on reproductive development at 399 and 435 days of age are presented in Table 2. Diameter of the largest follicle at 399 days of age was 30% greater in progeny born to adult dams compared to that in heifers born to 15 and 27M dams ($P = 0.04$). Moreover, at 435 days of age, heifers born to adult dams had follicles with diameters 15.7% greater than heifers born to 27M dams, and heifers born to 27M dams had follicles with diameters 18.7% greater than heifers born to 15M dams ($P = 0.004$).

At 399 days of age, RTS in heifers born to adult dams was greater compared to that in heifers born to 27M dams, and this category presented greater development than heifers born to 15M dams ($P = 0.02$, Table 2). At 453 days of age, heifers born to adult dams continued with a greater degree of RTS compared to heifers born to 27M dams; nevertheless, this category presented similar RTS to heifers born to 15M dams ($P = 0.03$). Percentage of heifers defined as pubertal at 399 days of age was not different among heifers from different ages of dam ($P = 0.33$). However, at 453 days of age, the progeny born to adult dams had a greater percentage of heifers defined as pubertal compared to the progeny born to 15 and 27M dams ($P = 0.04$). After ovarian synchronization at 16.5 months of age, the weight of uterus, ovaries and CL was not different due to the age of dam at calving ($P > 0.25$, Table 3). Also, the diameters and volumes of ovaries and CL were not different among heifers from dams of different ages ($P > 0.34$).

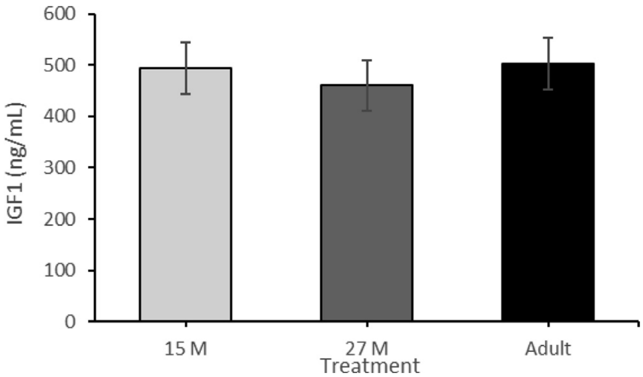

Fig. 2. Serum IGF-1 concentration from female progeny born to heifers pregnant at 15 months of age (15M), 27 months of age (27M) and multiparous cows (Adult) from weaning until 435 days of age. Values are means ± SEM. Age of dams, $P = 0.20$; time, $P < 0.0001$; age of dams × time, $P = 0.49$.

Author's point of view

- The main outcomes of this study are the following: (1) The 15M dams which reached 70.5% of Adult BW at the beginning of the experiment had calves 1.0 kg lighter at parturition than calves born to 27M dams. At the beginning of the experiment, dams which were bred at 27 months of age had 86% of Adult BW, and their calves were 2.0 kg lighter than calves born to adult dams at parturition. (2) At weaning, progeny born to adult dams were 23.6 kg heavier than progeny born to 27M dams and these were 32.6 kg heavier than progeny born to 15M dams. Adult dams from the present experiment produced more milk than primiparous dams, but the difference between primiparous dams was not observed. However, 27M dams produced a greater percentage of protein than that produced by 15M dams, and this could explain the greater weaning weight of the calves born to adult and 27M dams compared to the ones born to 15M dams (López Valiente et al., 2021). (3) In previous studies, we observed that increased average daily gain during preweaning stage was associated to a greater IGF-1 serum concentration (López Valiente et al., 2021). In the post-weaning stage, there were no differences in average daily gain between daughter from different ages of dams, and it was consistent with the lack of differences in circulating IGF-1 concentration in female progeny. (4) Heifers born to primiparous manifested a lower longissimus muscle area and a lower fat thickness than the heifers born to adult dams. (5) Age of dams at conception affected the LFD and RTS of female progeny, and LFD was always measured in both ovaries, and heifers born to adult dams had a greater LFD than heifers born to 15 and 27M dams in all cases. In addition, at 435 days of age, heifers born to 27M dams had a greater LFD than heifers born to 15M dams. (6) Heifers born to 27M dams showed greater reproductive development than heifers born to 15M dams at 399 days of age, but differences were not observed 36 days later. (7) At 495 days of age the reproductive organs evaluated did not present differences due to the age of the mother.
- The results of this study confirm that fetuses of heifers result of intra-uterine growth restriction, due to decreased nutrient transport or a result of intra-uterine crowding caused by smaller uterus in heifers (Bellows et al., 1982; Tenley et al., 2019). In the offspring of heifers, there is an evident retardation in fetal growth compared to the offspring of cows; however, this study allowed us to see that age at first gestation also has a strong influence on fetal development. However, although it is known that heifers wean calves that are lighter than adult cows, this study reveals the impact of age at first gestation on development during lactation may be even greater than the differences between primiparous and multiparous cows. The milk productions were consistent with prior findings documented in studies

Table 2
Effect of age at first gestation on heifer progeny reproductive development at 399 and 435 days of age.

	Age of dam[1]				
Item	15M	27M	Adult	SEM	*P*-Value
Diam fol[2] 399 days, mm	7.6[a]	7.6[a]	9.9[b]	0.05	0.04
Diam fol 435 days, mm	9.1[a]	10.8[b]	12.5[c]	0.06	0.004
RTS[3] 399 days	1.2[a]	1.8[b]	2.6[c]	0.3	0.02
RTS 435 days	2.2[a]	2.2[a]	3.2[b]	0.3	0.03
Pubertal at 399 days, %	0	0	14	–	0.33
Pubertal at 435 days, %	0[b]	0[b]	28[a]	–	0.04

Data presented as LSM ± SEM.
Abbreviations: 15M = dams were AI at 15 months of age; 27M = dams were AI at 27 months of age; Adult = dams were multiparous cows; Diam Fol = Follicle diameter; RTS = Reproductive Tract Score.
[a,b,c]Row means that do not have a common superscript differ, $P < 0.05$.

Table 3
Effect of age of dams at first gestation on reproductive organs characteristics of their heifer progeny.

	Age of dam[1]				
Item	15M	27M	Adult	SEM	*P*-Value
Uterus weight, g	183	221	193	16.4	0.25
Ovary weight, g	6.9	7.1	7.3	0.6	0.75
Ovary diameter, cm	33.9	34.2	31.0	2.1	0.37
Ovary volume, cm^3	101.4	101.6	97.3	5.3	0.61
CL[2] weight, g	3.5	3.7	3.4	0.5	0.65
CL Diameter, cm	21.9	22.3	20.3	1.6	0.34
CL Volume, cm^3	75.4	72.8	72.0	6.0	0.80

Data presented as LSM ± SEM.
Abbreviations: 15M = heifers were AI at 15 months of age; 27M = heifers were AI at 27 months of age; Adult = multiparous cows; CL = Corpora lutea.

focusing on multiparous beef cattle (López Valiente et al., 2018; Rodrigues et al., 2014) as well as heifers (López Valiente et al., 2019). Lower milk production of primiparous dams with respect to multiparous dams coincides with what was reported by Hansen et al. (1982) and López Valiente et al., 2021). During post-natal growth, IGF-I positively modulates protein synthesis rate and inhibits protein degradation contributing to increase BW (Oksbjerg et al., 2004). In this study, the lack of response in weight gain was also accompanied by a similarity in the concentration of IGF-I in heifers born to dams of different ages at pregnancy. Zheng et al. (2018) reached similar conclusions concerning IGF-1 concentration and its relationship with BW gain in finishing steers. This is due to IGF-I, which is a potent stimulator of tissue and body growth thus, IGF-1 stimulates body growth and plays an important role in mediating growth (Etherton and Bauman, 1998). The results found in Longissimus muscle area and subcutaneous fat are consistent with the combined effects of low fetal nutrition and milk consumption until weaning in heifers that were correlated with physical parameters of the calves' carcass such as longissimus muscle area and subcutaneous fat (Gandra et al., 2019). The reduction in LFD and RTS also agrees with the parity of dams (Tenley et al., 2019). However, the effect of age at first conception and its consequences on the reproductive development of female offspring has not been compared at early ages. Our results agree with those presented by (Greenwood et al., 2010), who reported that severe fetal growth retardation due to maternal undernutrition from early pregnancy cows was associated with decreased ovarian weight and follicles size in heifer progeny at 30 months of age. Thus, the heifers born to 15M would be less fertile than heifers born to 27M.

- During the stage with high level of energy concentration, all the heifer offspring increased their daily gain, and this possibly helped develop reproductive organs. Moreover, the heifers received a synchronization treatment to evaluate the development of the organs in the same phase of the estrous cycle. This could have favored the development of the ovaries, eliminating possible differences that they could have had if they had not been synchronized. Estradiol plays a positive role in the pubertal process, the exogenous administration of estradiol can cause precocious puberty in heifers (de Lima et al., 2020), since it modifies their hypothalamus, increasing the secretion of gonadotropins (Yavas and Walton, 2000) and inducing puberty (Júnior et al., 2010). Therefore, the exposure of heifers in this trial to an exogenous source of estradiol and P4 added to a diet with a high source of starch before the onset of puberty could have increased the development of the genital organs and produced the maturation of the organs of all heifers, since the differences were not found in the development of the uterus, ovaries, and sizes of corpora lutea. The available data presently preclude an examination of reproductive performance in subsequent years, a matter that may merit further investigation.
- The data can be available for researchers or producers involved in cattle breeding and management to select the more profitable female because the age of the heifer affected the reproductive development of the females. Thus, livestock producers can benefit from the insights to make informed decisions regarding the selection of replacement heifers based on the age of dams at first gestation.
- Future research can build upon this study by exploring the long-term reproductive performance of female progeny, extending the investigation beyond the first service to adult reproductive capabilities. Researchers may deeper into the molecular and physiological mechanisms underlying the observed effects, such as exploring specific nutrient pathway or hormonal regulation.

Conclusion

Numerous studies have been focalized to detect the differences in progeny performance of beef heifers versus multiparous dams; however, scarce studies have been designed to detect the effect of age at first gestation on female progeny performance and reproductive development. This study hasshown that age at which heifers were pregnant could affect the female progenies' development. The result of the present study indicates that age at first conception could influence the reproductive development of their progeny, and the adverse effects were more pronounced in offspring born to 15M. Thus, it is more convenient to select replacement heifers born to 27M than 15M and they had higher follicles diameters and reproductive tract score at early ages than heifers born to 15M. However, the use of heifer daughters of adult cows continues to be the most recommended due to their greater development and precocity than heifers born to 15 and 27M. Further research is required to better elucidate the reproductive response of female progeny during the first service and on adult reproductive performance.

Ethics approval

All procedures involving animals were approved by CICUAE INTA-CERBAS (Institutional Committee for Care and Use of Experimental Animals of South Buenos Aires Region), approval No. 161, and all methods were performed in accordance with the regulation.

Declaration of Generative AI and AI-assisted technologies in the writing process

The authors did not use any artificial intelligence-assisted technologies in the writing process.

Author ORCIDs

SLV: https://orcid.org/ 0000-0002-7743-2798.
AMR: https://orcid.org/ 0000-0001-6445-8780.
NML: https://orcid.org/ 0000-0002-0220-7318.
SM: https://orcid.org/ 0000-0003-2891-9492.

Author contributions

SLV: Funding acquisition, Project administration, Methodology, Investigation, Data curation, Formal analysis, Writing – review & editing; **AMR:** Methodology, Investigation, Visualization, Writing – review & editing; **NML:** Validation, Methodology, Formal analysis, Writing – review & editing; **SM:** Methodology, Investigation, Data curation, Validation, Visualization, Writing – review & editing.

Declaration of interest

Sebastian Lopez-Valiente reports financial support was provided by Institute for the Promotion of Argentinian Beef (IPCVA) and National Institute of Agricultural Technology (INTA). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank our colleagues from the Colonia Ortiz Basualdo (INTEA) experimental facility for handling execution of the experiment.

Financial support statement

This work was supported by Instituto de la Promoción de la Carne Vacuna Argentina (IPCVA, announcement year 2018) and National Program of Animal Production (PNPA1126023; CIAC 940174) of National Institute of Agricultural Technology (INTA), Argentina.

References

Akbarinejad, V., Gharagozlou, F., Vojgani, M., Bagheri Amirabadi, M.M., 2018. Nulliparous and primiparous cows produce less fertile female offspring with lesser concentration of anti-Müllerian hormone (AMH) as compared with multiparous cows. Animal Reproduction Science 197, 222–230. https://doi.org/10.1016/j.anireprosci.2018.08.032.

Bellows, R.A., Short, R.E., Richardson, G.V., 1982. Effects of sire, age of dam and gestation feed level on dystocia and postpartum reproduction. Journal of Animal Science 55, 18–27.

de Lima, R.S., Martins, T., Lemes, K.M., Binelli, M., Madureira, E.H., 2020. Effect of a puberty induction protocol based on injectable long acting progesterone on pregnancy success of beef heifers serviced by TAI. Theriogenology 154, 128–134. https://doi.org/10.1016/j.theriogenology.2020.05.036.

Etherton T.D. Bauman D.E. 1998. Biology of Somatotropin in growth and lactation of domestic animals. J. Physiological Reviews 78, 745-761. https://journals.physiology.org/doi/abs/10.1152 /physrev.1998.78.3.745.

Gandra, J.R., Seno, L.O., Borquis, R.R.A., Escobar, A.Z., de Oliveira, E.R., Santos, R.J.A., Cônsolo, N.R.B., Acosta, A.P., 2019. Milk yield and composition of primiparous recipient cows influence the performance and carcass ultrasonography of Nellore calf. Journal of Applied Animal Research 47, 506–513. https://doi.org/10.1080/09712119.2019.1675668.

Greenwood, P. L., Bell, a, Vecoe, P. E., Viljoen, G. 2010. Managing the Prenatal Enviroment to Enhanced Livestock Productivity. https://doi.org/10.1007/978-90-481-3135-8.

Hansen, P.J., Baik, D.H., Rutledge, J.J., Hauser, E.R., 1982. Genotype x environmental interactions on reproductive traits of bovine females. II. Postpartum reproduction as influenced by genotype, dietary regimen, level of milk production and parity. Journal of Animal Science 55, 1458–1472. https://doi.org/10.2527/jas1982.5561458x.

Holm, D.E., Thompson, P.N., Irons, P.C., 2009. The value of reproductive tract scoring as a predictor of fertility and production outcomes in beef heifers. Journal of Animal Science 87, 1934–1940. https://doi.org/10.2527/jas.2008-1579.

Júnior, I.C., Filho, O.G.S., Peres, R.F.G., Aono, F.H.S., Day, M.L., Vasconcelos, J.L.M., 2010. Reproductive performance of prepubertal Bos indicus heifers after progesterone-based treatments. Theriogenology 74, 903–911. https://doi.org/10.1016/j.theriogenology.2010.04.015.

López Valiente, S., Maresca, S., Rodríguez, A.M., Palladino, R.A., Lacau-Mengido, I.M., Long, N.M., Quintans, G., 2018. Effect of protein restriction of Angus cows during late gestation: subsequent reproductive performance and milk yield. Professional Animal Scientist 34. https://doi.org/10.15232/pas.2017-01701.

López Valiente, S., Maresca, S., Rodríguez, A.M., Long, N.M., Quintans, G., Palladino, R.A., Valiente, S.L., 2019. Effect of protein restriction during mid-to late gestation of beef cows on female offspring fertility, lactation performance and calves development. EC Veterinary Science 4, 01–12.

López Valiente, S., Rodríguez, A.M., Long, N.M., Quintans, G., Miccoli, F.E., Lacau-Mengido, I.M., Maresca, S., 2021. Age at First Gestation in Beef Heifers Affects Fetal and Postnatal Growth, Glucose Metabolism and IGF1 Concentration. Animals (Basel). 11 (12), 3393. https://doi.org/10.3390/ani11123393. PMID: 34944170; PMCID: PMC8697898.

Nuñez-Dominguez, R., Cundiff, L.V., Dickerson, G.E., Gregory, K.E., Koch, R.M., 1991. Lifetime production of beef heifers calving firsta at two versus three years of Age. Journal of Animal Science 69, 3467–3479. https://doi.org/10.2527/1991.6993467x.

Oksbjerg, N., Gondret, F., Vestergaard, M., 2004. Basic principles of muscle development and growth in meat-producing mammals as affected by the insulin-like growth factor (IGF) system. Domestic Animal Endocrinology 27, 219–240. https://doi.org/10.1016/j.domaniend.2004.06.007.

Petraitiene, I., Valuniene, M., Jariene, K., Seibokaite, A., Albertsson-Wikland, K., Verkauskiene, R., 2020. Sex hormones, gonad size, and metabolic profile in adolescent girls born small for gestational age with catch-up growth. Journal of Pediatric and Adolescent Gynecology 33, 125–132. https://doi.org/10.1016/j.jpag.2019.11.001.

Rodrigues, P.F., Menezes, L.M., Azambuja, R.C.C., Suñé, R.W., Barbosa Silveira, I.D., Cardoso, F.F., 2014. Milk yield and composition from Angus and Angus-cross beef cows raised in southern Brazil. Journal of Animal Science 92, 2668–2676. https://doi.org/10.2527/jas2013-7055.

Tenley, S.C., Gomes, R.S., Rosasco, S.L., Northrop, E.J., Rich, J.J.J., McNeel, A.K., Summers, A.F., Miles, J.R., Chase, C.C., Lents, C.A., Perry, G.A., Wood, J.R., Cupp, A. S., Cushman, R.A., 2019. Maternal age influences the number of primordial follicles in the ovaries of yearling Angus heifers. Animal Reproduction Science 200, 105–112. https://doi.org/10.1016/j.anireprosci.2018.12.004.

Wagner, J.J., Lusby, K.S., Oltjen, J.W., Rakestraw, J., Wettemann, R.P., Walters, L.E., 1988. Carcass Composition in Mature Hereford Cows: Estimation and Effect on Daily Metabolizable Energy Requirement during Winter. J. Anim. Sci. 66, 603–612. https://doi.org/10.2527/jas1988.663603x.

Yavas, Y., Walton, J.S., 2000. Postpartum acyclicity in suckled beef cows: a review. Theriogenology 54, 25–55. https://doi.org/10.1016/S0093-691X(00)00323-X.

Zheng, W., Leng, X., Vinsky, M., Li, C., Jiang, H., 2018. Association of body weight gain with muscle, fat, and liver expression levels of growth hormone receptor, insulin-like growth factor I, and beta-adrenergic receptor mRNAs in steers. Domestic Animal Endocrinology 64, 31–37. https://doi.org/10.1016/j.domaniend.2018.03.008.