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Impact of age at first calving on performance and economics in commercial dairy herds in Argentina

M.P. Turiello[a,*], C. Vissio[a,b], A.J. Heinrichs[c], L.C. Issaly[a], A. Larriestra[a,d]

[a] Facultad de Agronomía y Veterinaria, Universidad Nacional de Río Cuarto, Ruta nacional 36 km 601, Río Cuarto 5800, Córdoba, Argentina
[b] Instituto para el Desarrollo Agroindustrial y de la Salud (IDAS), UNRC-CONICET, Ruta Nacional 36 km 601, Río Cuarto 5800, Córdoba, Argentina
[c] Department of Animal Science, The Pennsylvania State University, University Park 16802
[d] Universidad Nacional de Villa María, Av. Arturo Jauretche 1555, Villa María 5900, Córdoba, Argentina

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ABSTRACT

Dairy herd efficiency depends on an adequate replacement program, and one of the main management factors affecting the replacement cost is age at first calving (**AFC**). The primary objective of this study was to evaluate the impact of AFC on performance and economic results in commercial dairy herds in Argentina. A retrospective study was conducted to analyze data from a total of 26,614 first lactation cows from 290 argentinian dairy farms calved for the first time during the calendar year 2016. Milk yield for first lactation cows having at least 5 milk test days was used to analyze production ($n = 15{,}181$). Records were stratified by AFC into 5 groups: 1) 18–21 mo ($n = 202$), 2) 22-25 mo ($n = 5{,}569$), 3) 26-29 mo ($n = 5{,}579$), 4) 30-33 mo ($n = 2{,}389$), 5) 34-37 mo ($n = 1{,}442$). The overall median of AFC was 27 mo. Although milk yield at the beginning of the lactation was lower for lower AFC categories, the differences between categories 2, 3, and 4 disappeared by the fourth test day at approximately 113 days in milk. No effect of AFC category was detected for milk fat and protein content and for SCC. Considering AFC categories, cows calving for the first time at 22–25 mo of age needed the shortest period after calving to conceive. The lower income associated with the mild milk losses may be compensated by the cost of more than 80 extra d in the rearing period and the increment in days open estimated for the upper categories.

1. Introduction

Dairy herd efficiency depends on an adequate replacement program. In turn, the replacement process can represent 20-30% of the herd production costs (Karszes et al., 2008) and requires large investment for a long period of time (Heinrichs, 1993). The magnitude of the rearing costs relays on growth performance (Bach and Ahedo, 2008), reproductive efficiency (Gabler et al., 2000), and the mortality rate (Tozer and Heinrichs, 2001). The latter authors found that the main management factors affecting the replacement cost were herd culling rate and age at first calving (AFC), while Bach et al. (2008) listed AFC as one of the four main variables that accounted for more than 50% of the variation in milk production observed between herds, highlighting its importance.

Age at first calving is a function of age at first breeding and reproductive performance (Ettema and Santos, 2004). Age at first breeding depends on the farmer's criteria to initiate breeding and can be modified through management and feeding strategies that make changes in the growing rate of the heifers. In Argentina, as a result of a survey, Schuenemann et al. (2016) concluded that a defined criterion to initiate breeding in replacement heifers was one of the variables most tightly associated with increased total herd milk production. Lack of defined criteria to initiate breeding in heifers at the farm level seems to be a problem in addition to growth of heifers in dairy herds. In the 1980s, some studies with heifers (Lin et al., 1985, 1987; Gardner et al., 1988) proposed a reduction in age at first breeding as a strategy to improve the economics at the farm level, although later, farmers realized this change should be accompanied by other management strategies to avoid affecting productive results (Mohd Nor et al., 2013). Zanton and Heinrichs (2005) recommended limiting prepubertal growth rate to 800 g/d to maximize first lactation milk yield, and this rate fits in well with the desired growth needed for reaching first calving.

Age at first calving was previously positively associated with milk yield (Pirlo et al., 2000; Berry and Cromie, 2009; Hutchison et al., 2017) but some observational studies found a negative

* Corresponding author at: Ruta nacional 36 km 601, Río Cuarto 5800, Córdoba, Argentina.
E-mail address: mpturiello@ayv.unrc.edu.ar (M.P. Turiello).

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(Froidmont et al., 2013) or no effect of delaying AFC on milk yield (Heinrichs and Vazquez-Anon, 1993; Ettema and Santos, 2004). This may reflect changes in feeding programs; however, it is also likely in part due to genetic selection that has been occurring in the breeds. In terms of reproductive efficiency, conception rate at first service was reduced in cows calving for the first time before 23 mo of age (Ettema and Santos, 2004). There are also opposite results regarding AFC and stillbirth rate or dystocia (Thompson et al., 1983; Hoffman et al., 1996; Ettema and Santos, 2004; Hutchison et al., 2017).

When modeling milk production and reproductive performance under different AFC, Hutchinson et al. (2017) found the best indicators at 21–22 mo of age for Holstein and 20–21 mo of age for Jerseys first lactation cows, considering lifetime productivity. In this study and the one from Pirlo et al. (2000) a delay in AFC after 22 or 23 mo of age, respectively, led to increased rearing costs and diminished income opportunity.

We hypothesized that AFC is associated with productive and reproductive performance during the first lactation. Knowing the consequences of delaying AFC would help consultants to focus on this strategy at farm level. The primary objective of this study was to evaluate the association between AFC and production, reproduction, and milk quality traits during the first lactation in argentinian dairy farms. Additionally, we described the economic consequences of different AFC compared to the recommendation (22–25 mo).

2. Materials and methods

A retrospective study was conducted to analyze data from a total of 26,614 first lactation cows calved for the first time during the calendar year 2016. Data was provided by the Asociación Regional Centro in Córdoba province, Argentina, which enrolls official milk testers of the province and gathers productive and reproductive data from 290 dairy farms (~8% of the total herds of the province).

Age at first calving was calculated by subtracting the cow`s birth date from its first calving date. A total of 3,389 first lactation cows were excluded because they were either less than 18 or more than 37 months of AFC, considering these could be registry errors.

Milk yield for first lactation cows having at least 5 milk test days was used to analyze production. The time interval between calving and the first test day, or between 2 test days was 1 to 50 d. First lactation cows with < 100 accumulated DIM and farms with < 4 registries were excluded. A total of 15,181 first lactation cows were included in the analysis.

Records were assigned by AFC into 5 groups: 1) 18–21 mo (n = 202), 2) 22–25 mo (n = 5,569), 3) 26–29 mo (n = 5,579), 4) 30–33 mo (n = 2,389), and 5) 34–37 mo (n = 1,442). As AFC is usually considered economically optimum for Holstein first lactation cows when they calve at 22 to 24 mo of age (Heinrichs, 1993; Hutchinson et al., 2017) or 23 to 25 mo of age (Nilforooshan and.Edriss, 2004), this criterion was used to primarily define the AFC categories.

Herds (n = 214) were categorized according to the number of first lactation cows using the quartiles as cut-points: 1) 4-–26 (n = 55), 2) 27–92 (n = 105), and 3) 97-883 (n = 54). Calving dates were grouped in seasons: winter (n = 5,322, June 1 to August 31), spring (n = 3,031, September 1 to November 30), summer (n = 2,161, December 1 to February 28), and autumn (n = 4,857, March 1 to May 31).

Total milk production was calculated multiplying milk yield (MY) at the test day by the number of days between that test day and the previous one (or the calving day if it was the first test) and accumulating 5 test days. Daily mean MY (kg/d) was obtained dividing total milk production by accumulated days for each first lactation cow. Start-up milk yield was defined as the milk yield at the first test day. The highest milk yield during the 5 test days was considered as the peak milk yield and the DIM at that test day was defined as the DIM at peak.

The association of AFC with milk fat, protein, and SCC was estimated using data from 10,302, 9,238, and 5,583 first lactation cows, respectively. A natural logarithmic transformation of SCC was used to approximate the normal distribution (Ali and Shook, 1980).

Data from 15,731 first lactation cows was initially included in the analysis to explore the association between AFC and reproduction parameters. Of the original records, 14,454 had reproductive data, and from them, data from first lactation cows with a minimum of 50 DIM at first service were included in the final analysis of reproductive data (n = 12,024). Non-pregnant first lactation cows at 305 DIM were considered open.

A general linear mixed model described in Eq. (1) was applied to estimate differences in start-up, peak, and daily mean milk yield, days at peak, milk fat and protein content, SCC, days to first service, days open, and services per conception. We included the fixed effects of AFC category, calving season, herd size category, and their interactions when significant, and the random effect of farm:

$$y_{ijklm} = \mu + A_i + S_j + H_k + f_l + e_{ijklm} \tag{1}$$

where, y_{ijklm} = the value of the dependent variable (i.e. start-up milk yield), μ = the overall mean, A_i = the effect of the ith category of AFC (i = 1, 2, 3, 4, or 5), S_j = the effect of the jth season of calving (j = summer, spring, autumn, or winter), H_k = the effect of the kth herd size category (k = 1, 2, or 3), f = the random effect of farm, and e_{ijklm} = the residual random error. All 2-way interactions between fixed factors were evaluated and retained if P-value was ≤ 0.05 (Dohoo et al., 2003).

A general linear mixed model described in equation 2, was applied to estimate the association between AFC and milk production during the 5 milk test days of the first lactation. We included the fixed effects AFC category, calving season, herd size category, number of the milk test, and their interactions when significant, and the random effect of cow nested within farm:

$$y_{ijklmno} = \mu + A_i + S_j + H_k + T_l + c_m(f_n) + e_{ijklmno} \tag{2}$$

where, $y_{ijklmno}$ = the value of the dependent variable (milk yield), μ = the overall mean, A_i = the effect of the ith category of AFC (i = 1, 2, 3, 4, or 5), S_j = the effect of the jth season of calving (j = summer, spring, autumn, or winter), H_k = the effect of the kth category of herd size (k = 1, 2, or 3), T_l = the effect of the lth number of the milk test (l = 1, 2, 3, 4, or 5), $c_m(f_n)$ = the random effect of cow nested within farm, and $e_{ijklmno}$ = the residual random error. We considered an autoregressive of order 1 covariance structure, chosen based on Akaike's information criterion.

The LSD Fisher method was used for means comparison in both models when the test resulted in a P-value ≤ 0.05. All the analysis were performed in InfoStat (Di Rienzo et al., 2018).

The difference between reproductive performance according to AFC categories was described by applying a Kaplan-Meyer analysis (Dohoo et al., 2003). In order to assess association between AFC and days open during the first lactation, a Cox proportional regression model (Dohoo et al., 2003) was fitted with AFC as a main effect and herd size category as an adjusting variable. Assumptions on the proportional hazard risk were verified as suggested by Dohoo et al. (2003). Additionally, a frailty model considering herd as a random effect was further adjusted. The best fitting model was selected based on Akaike's information criterion.

As proposed by Pirlo et al (2000), to evaluate the economic impact (EI) of AFC, a deterministic simulation was developed including milk income (MI), rearing costs (RC) and reproductive costs (RepC):

$$EI_{cat2-i} = MI_{cat2-i} - (RC_{cat2-i} + RepC_{cat2-i}) \tag{3}$$

where, EI = economic impact, MI = milk income, RC = rearing costs, RepC = reproductive costs. Variables were expressed as the difference of each AFC category relative to the 2nd AFC category in \$/cow ($_{cat2-i}$).

We estimated 305-day MY for the average first lactation cow of each AFC category using estimates derived from the mixed model described above, and using the web tool Milk Curve Fitter (Wood´s model) developed by the Department of Dairy Science, University of Wisconsin-Madison 2011 (https://dairymgt.info/tools/mcf_online/index.php, last access on April 2020). Milk income was calculated multiplying the price of 1 kg of milk by the difference between the 305-d MY of cows calving for the first time at 22 to 25 mo of age (2nd AFC category) and the 305-d MY of each of the other categories. The milk price was the average paid to the argentine farmers during calendar year 2016 (OCLA, 2019). The lactation was standardized at 305-d, in order to compare total income with total cost per cow.

To calculate the RC, a cost analysis spreadsheet was developed with an Excel '97 Microsoft file. The proposal of Martin and Demateis Llera (2017) was used as a guide. This tool was designed to estimate the costs involved in the breeding and rearing costs of a heifer from birth to calving. Information of technical coefficients was obtained from local qualified informants, and then the physic information was expressed in monetary values. Expenses prices were provided by local technicians and were representative of Córdoba province (2016 average prices). The modeling started from a 100 total cow's herd, with a 25% of dry cows in the herd and 50% of females calves born. Mortality rate was 5% (no replacement was considered). All these values reflected local conditions in dairy production and could be changed. Costs included feed, labor, health, reproduction, amortizations of durable goods, and interests for fixed and working capitals immobilized in the corresponding periods, according to Frank (1985) methodology. Feed cost included milk, grains, silages, and pastures. For these latter two items, the opportunity cost for the use of the land was included. For labor cost it was supposed that an operator dedicated 30% of his labor time to dairy operations and was calculated based on official wages values. Items in health costs reflected the standard prevention and control program in the region. The estimation of RC also included artificial insemination (supplies and veterinary services). The amortizations of durable goods (equipment and tools) were estimated through a straight-line depreciation. Interests were estimated by different rates according capitals were fixed or working capitals and the immobilization time. The RC was estimated considering age classes: birth to weaning (0-2 mo of age), weaning to 6 mo of age, and 6 mo to age to calving (which varied according to AFC category). Rearing costs per cow were calculated for each AFC category and compared to AFC category 2.

The RepC represented the cost of involuntary days open, and this was estimated using the model provided by Cattaneo et al. (2015), who considered milk yield loss due to involuntary extended lactation (estimated with 305-day MY of each category), calf crop loss (calculated as the average female and male prices divided by calving interval), additional reproductive interventions (extra veterinary services and artificial insemination issues), additional labor costs (extra labor journals in official wages and values) and cow replacement costs due to infertility (difference in prices between replacement heifer and culled cow adjusted by average infertility culling rate and divided by involuntary days open). It was also included the additional interest cost due to the immobilization of working capitals. As no extra durable goods were used, no amortizations were considered. The cost was adjusted to local conditions practices and 2016 prices, and was multiplied by the difference in days open by AFC category compared to category 2.

In order to contribute to the decision making, a sensitivity analysis with 2 scenarios of milk price and costs, were calculated: 1) optimistic scenario, milk price was increased and costs were decreased 10%, and 2) pessimistic scenario, milk price was reduced and costs were increased 10%.

3. Results

The overall median and interquartile range of AFC for this data set was 27 and 25–30 mo, respectively (Table 1), and farm medians ranged from 23 to 36 mo. More than half of the cows (56%) calved for the first time from April 1 to August 31. The month with the fewest calvings was January. A summary of productive and reproductive variables of the data set is presented in Table 1.

Table 1
Descriptive statistics of age at first calving, milk yield, milk quality and reproductive indicators during the first lactation for cows calving for the first time in 2016.

	n	Median (interquartile range)
Productive indicators		
AFC[1] (mo)	15,181	27.0 (25.0-30.0)
Milk yield[2] (kg/d)	15,181	27.1 (23.0-31.0)
Milk fat (%)	10,302	3.47 (3.13-3.64)
Milk protein (%)	9,238	3.29 (3.18-3.42)
Somatic cell count[3]	5,583	4.46 (3.82-5.12)
Reproductive indicators		
Days to first service	9,752	79 (63-113)
Days open	9,752	131 (85-213)
Services per conception	9,752	2.0 (1.0-3.0)

[1] Age at first calving.
[2] Average milk yield among the first 5 test days.
[3] Natural logarithm of somatic cell count.

3.1. Milk production

Median MY per first lactation cow was 27.1 kg/d (Table 1), and farm averages ranged from 14 to 41 kg/d. Table 2 shows the least square means for the productive variables. No differences between AFC categories in neither accumulated days in milk (DIM), nor DIM at each test day were detected (P-value > 0.1). Milk yield, start-up, and peak milk yield increased systematically from the first to the fifth AFC category (P-value < 0.05). The highest difference in MY (1.7 kg/d) was detected between the first and second AFC categories and the lowest between the second and third (0.6 kg/d) and the third and fourth (0.5 kg/d) AFC categories. The same trend was observed for start-up milk and peak milk yield. First lactation cows from different AFC categories did not differ in their DIM at peak.

Milk production adjusted by herd size and calving season for the 5 AFC categories according to milk test day, is shown in Figure 1. Although milk yield at the beginning of the lactation was lower for lower AFC categories, the differences between categories 2, 3, and 4 disappeared by the fourth test day at approximately 113 DIM.

3.2. Milk quality

An interaction between calving season and AFC category was detected for milk fat and protein content and for SCC. No clear pattern was observed for any of these variables. AFC category 2 did not show a significant difference with the other categories for milk quality traits adjusted by calving season. The effect of herd size category was not significant in the final models.

3.3. Reproduction

As shown in Table 1, 50% of the first lactation cows were open for a period of at least 131 d and needed 2 services per conception. Considering AFC categories, cows calving for the first time at 22-25 mo of age needed the shortest period after calving to conceive (Table 2).

The likelihood of being non-pregnant according to DIM for different AFC categories is shown in Figure 2. AFC category 2 has a clearly more pronounced slope than the others. In fact, 50% of the first lactation cows in this category were pregnant at 138 DIM, compared with 150 DIM for cows in the third AFC category.

Fitting the Cox regression model adjusted by herd size, first lactation cows within AFC category 2 showed significant differences with categories 1 and 3 in days open. Age at first calving categories 3 and 4 showed a relative risk (RR) of becoming pregnant 6 (RR = 0.94, CI 95%

Table 2
Estimates (mean ± SE) of productive indicators according to age at first calving (AFC) category[1], during the 5 milk test days in the first lactation[2].

	AFC category				
	1	**2**	**3**	**4**	**5**
n	202	5,569	5,579	2,389	1,442
AFC (mo)	20.8 ± 0.1[a]	24.2 ± 0.03[b]	27.3 ± 0.02[c]	31.3 ± 0.03[d]	35.2 ± 0.03[e]
DIM (d)	146.1 ± 1.33	145.8 ± 1.05	145.8 ± 1.05	146.0 ± 1.06	146.5 ± 1.09
MY[2] (kg/d)	23.0 ± 0.47[a]	24.7 ± 0.33[b]	25.3 ± 0.33[c]	25.8 ± 0.33[d]	26.5 ± 0.34[e]
Start-up milk yield (kg)	19.6 ± 0.56[a]	21.4 ± 0.30[b]	22.0 ± 0.29[c]	22.4 ± 0.31[d]	22.9 ± 0.33[d]
Peak milk yield (kg)	26.4 ± 0.51[a]	28.6 ± 0.36[b]	29.3 ± 0.36[c]	29.9 ± 0.37[d]	30.9 ± 0.38[e]
DIM at peak (d)	85.4 ± 2.89	87.0 ± 1.10	86.6 ± 1.07	85.2 ± 1.20	85.6 ± 1.39
Days open (d)	180.8 ± 7.35	166.8 ± 0.14	173.3 ± 1.40	186.0 ± 2.17	187.0 ± 2.70

[a] Superscripts in the same row differ (P-value $\leq$ 0.05)
[b] Superscripts in the same row differ (P-value $\leq$ 0.05)
[c] Superscripts in the same row differ (P-value $\leq$ 0.05)
[d] Superscripts in the same row differ (P-value $\leq$ 0.05)
[e] Superscripts in the same row differ (P-value $\leq$ 0.05)
[1] Age at first calving categories: 1) 18-21 mo, 2) 22-25 mo, 3) 26-29 mo, 4) 30-33 mo, 5) 34-37 mo.
[2] Average milk yield among the first 5 test days.

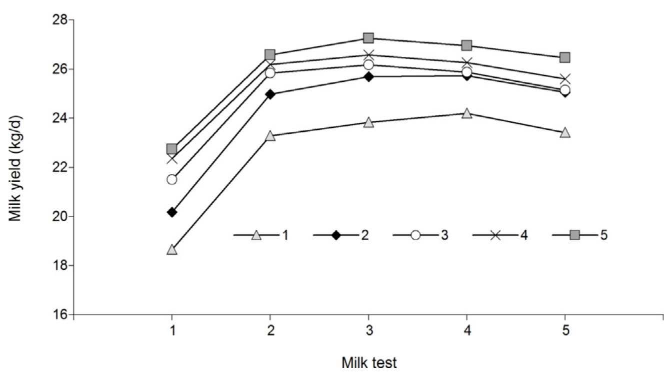

Fig. 1. Least square means of milk yield (kg/d) in the first 5 milk test days among cows that calved for the first time at different ages. Age at first calving (AFC) categories: 1) 18–21 mo (n=202), 2) 22–25 mo (n=5569), 3) 26–29 mo (n=5579), 4) 30–33 mo (n=2389), 5) 34–37 mo (n=1442). Significant effects: age group (P-value < 0.0001); milk test day (P-value < 0.0001); age group by milk test (P-value < 0.0001); herd size group (P-value < 0.0001) and season (P-value < 0.0001).

0.89-0.99; P-value= 0.026) and 11% (RR = 0.89, CI 95% 0.83-0.96; P-value = 0.001) higher than AFC category 2, respectively. No differences were detected between AFC categories 1 and 2 (RR=0.92, CI 95% 0.76-1.12; P-value= 0.42), and a 9% difference was found between AFC categories 2 and 5 (RR 0.91 CI 95% 0.83-1.0, P-value= 0.059).

3.4. Economics

The EI of AFC is presented in Table 3. There was an increment of MI but also an increase in RC when calving was delayed; in contrast, these variables were lower in AFC 1. In addition, the RepC were greater in all AFC categories compared to category 2 because the open days of the latter were the lowest. Finally, as cows calving for the first time younger than recommended had a greater decrease in MI than the decrease in the other evaluated costs, it resulted in a negative EI. The first lactation cows calving older than recommended (categories 3, 4 and 5) had also a negative EI because the increase in RC and RepC was greater than the increase in MI.

In the evaluated scenarios of milk price and costs, when considering an optimistic scenario, the EI of cows in AFC category 1 was negative reaching 43 $/cow; whereas the EI of older first calving cows was negative in 91, 108 and 181 $/cow for AFC categories 3, 4 and 5,

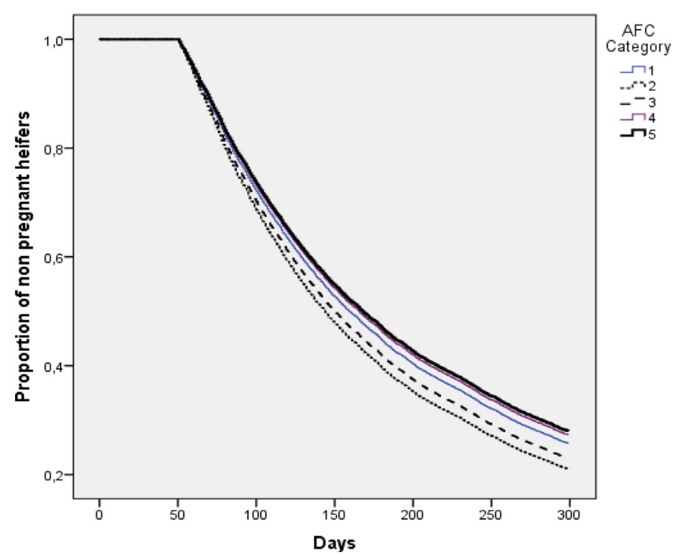

Fig. 2. Proportion of non-pregnant first lactation cows according to the day in milk for different age at the first calving categories. Non-pregnant first lactation cows were registered at 305 DIM or when left the study because of culling or death. Age at first calving (AFC) categories: 1) 18–21 mo (n=202), 2) 22–25 mo (n=5569), 3) 26–29 mo (n=5579), 4) 30–33 mo (n=2389), 5) 34–37 mo (n=1442).

Table 3
Economic results of age at first calving category compared to category 2 during the first lactation.

	AFC[1] category				
	1	**2**	**3**	**4**	**5**
Milk income deviation[2], $/cow	-96,84	0	18,09	139,99	154,52
Rearing costs deviation, $/cow	-85,13	0	80,82	185,57	288,54
Days open costs deviation, $/cow	14,00	0	42,00	105,00	101,50
Economic impact[3], $/cow	-25,71	0	-104,73	-150,58	-235,52

[1] Age at first calving categories: 1) 18-21 mo, 2) 22-25 mo, 3) 26-29 mo, 4) 30-33 mo, 5) 34-37 mo.
[2] Milk income deviation calculated based on milk price of 0.263$/L and the estimated 305-day MY of each AFC category, compared to category 2.
[3] Economic impact, calculated as milk income deviation minus rearing and reproductive costs deviation.

respectively. Under a pessimistic scenario, all the AFC categories other than recommended had a negative EI of 9, 119, 194 and 290 $/cow for AFC categories 1, 3, 4 and 5, respectively. This last scenario showed that the higher the AFC category, the worst the EI.

4. Discussion

An average AFC of 27.4 mo was found for the first lactation cows enrolled in this study, and 75% calved for the first time after 25 mo of age. The average AFC was higher than in most studies (Nilforooshan and Edriss, 2004; Berry and Cromie, 2009; Heinrichs et al., 2013; Mohd Nor et al., 2013; Krpálková et al., 2014; Hutchison et al., 2017; Heise et al., 2018) of many other countries and far from the economically optimum of 21 to 25 mo of age suggested by Heinrichs (1993), Hutchinson et al. (2017) and Nilforooshan and.Edriss (2004). Moreover, the variability of this data set is also high compared with those studies. These are the first data published on AFC for argentinian herds; as a result, the evolution of this indicator cannot be analyzed over time. In other countries like the United States, the proportion of animals calving at the recommended AFC has been increasing over the years (Heinrichs et al., 2017).

We also observed great variability in mean milk production between herds, which offers the potential to increase benefits. Farms with a lower mean AFC usually had a higher daily mean MY (data not shown) which may be related to better general farm management. This may also reflect forage management, which affects both animal growth and milk production.

When MY was adjusted by calving season and herd size category, younger cows at first calving produced less milk than older ones, which is consistent with previous studies (Pirlo et al., 2000; Berry and Cromie, 2009) where heifer growth or body size were an issue. Nevertheless, Froidmont et al. (2013) found greater milk production during the first lactation at calving ages of 22 to 26 mo of age compared to older first calving cows, and they also highlighted the negative effect of earlier calving on milk production. Comparing cows calving for the first time at 27.3 mo of age (AFC category 3) with those calving at 24.2 mo (AFC category 2), the latter produced 88 kg less milk.

In a recently published review (Heinrichs et al., 2017), the authors concluded that calving at 22 to 24 mo is economically optimum considering growth costs and lifetime milk production. In our study, the delay in AFC from that optimum, although generated a gain in milk produced it determined a net loss because of rearing and reproduction costs.

Prepubertal growth rate showed a positive association with milk production in a meta-analysis conducted by Zanton and Heinrichs (2005), although Van De Stroet et al. (2016) found that structural growth is better related to milk yield than BW. According to Heinrichs and Heinrichs (2011), other factors besides AFC seem to affect milk production during the first lactation.

In our study, different milk yield between AFC categories was detected at the beginning of the lactation but after 100 DIM these differences disappeared in cows calving for the first time at 22 to 32 mo of age. Similar results were found by Krpálková et al. (2014), who estimated a reduction in milk production during the first 100 d of the first lactation in cows calving younger than 23 mo of age compared to those being 24.7 or greater mo of age. These authors suggested that it might have been due to low BW or BCS at calving, since such first lactation cows must partition the energy to growth instead of milk production. Cows calved younger for the first time, might have weighed less and might have needed to continue growing for a few months, spending energy in growth at the expense of producing milk. In contrast, after approximately 100 days, those might have reached the same development to produce the same amount of milk as their herdmates.

As reported by the Argentinian Milk Observatory in a recent national monthly report, mean milk fat and protein percentage are 3.5 and 3.25%, respectively (OCLA, 2019). In our study, as in most studies (Ettema and Santos, 2004; Froidmont et al., 2013; Krpálková et al., 2014), no clear effect of AFC on milk fat and protein percentage was found. In contrast, Pirlo et al. (2000) found an opposite trend in fat and protein percentages: while protein content decreased, fat content increased with AFC increments. They argued that these results could be related to different abilities of young and old first lactation cows to select among gross forage and concentrate, changing milk composition. The median values of SCC were similar to those reported by Vissio et al. (2017) in Argentina. We found an interaction between AFC category and calving season, but we could not detect an effect of AFC on SCC. Berry and Cromie (2009) did not find an effect in cows calving for the first time during spring, but Eastham et al. (2018) found a positive association between AFC and SCC.

Similar reproductive descriptive findings in days open were published previously by Haumann and Wattiaux (1999). The number of days open was affected by AFC category, with younger first lactation cows (AFC category 2) having shorter periods. A higher proportion of young first lactation cows was pregnant at 305 DIM. This is consistent with the results of Ettema and Santos (2004), who found the shortest open period in cows calving for the first time at 23–25 mo of age. Hutchinson et al. (2017) also found a positive correlation between earlier AFC and fertility traits. The increase in days open comparing AFC categories 2 and 3 would represent a total loss of 538 kg of milk in the whole lactation, in terms of costs for this involuntary delayed pregnancy (Cattaneo et al., 2015); half of cows in category 2 were pregnant at 138 DIM, compared with 150 DIM for the third AFC category. A decreasing risk of being pregnant was detected as AFC increased from category 2 to 4. Although we expected a higher difference between 2 and 5, it seems to be a depression in the effect of increasing AFC in this category. In their study, Krpálková et al. (2014) found a reduced reproduction performance during the first lactation in older calving cows, attributing these results to the higher BCS of older cows and their subsequent potential health issues. Because of the study design, we are not able to get information about other predictors that could help to explain such effect in the oldest AFC category.

From an economic standpoint, comparing cows calving for the first time after 25 mo with those calving between 22 and 25 mo, differences in MI were detected but compensated by lower RC due to the shortening of the rearing period, and the improved reproductive performance. As concluded by Tozer and Heinrichs (2001), AFC is one important factor affecting rearing costs. They argued that with lower average AFC, producers shorten the replacement period and may also have eventually a surplus of heifers to sell. In our study, cows calving for the first time younger than recommended also showed a negative EI, primarily because of the lower MY, suggesting a lack of development in those first lactation cows, allocating nutrients to growth instead of milk during lactation. The sensitivity analysis showed the robustness of these results: similar trends in EI were found in the evaluated scenarios (optimistic and pessimistic). Considering that these scenarios could frequently occur in local economic conditions (Alasino and Arana, 2014; Gastaldi et al, 2016), advice to achieve the recommended AFC category (22–25 mo) was reinforced. One of the caveats of this study was the lack of any predictor other than age. In this sense it would be relevant to design a survey to assess a herd level predictor of AFC delay among argentinan dairy herds.

5. Conclusions

Increasing the AFC consistently showed an increase in milk yield, although as the cows calved for the first time older, they had more days open during their first lactation. The delay in AFC involved greater costs due to the extended rearing period and the longer calving to conception interval during first lactation, both costs being higher in magnitude than the extra milk income.

The results of this study on argentinian dairy herds show there is a great opportunity for consultants and producers to optimize the replacement program, getting closer to the recommended AFC.

Credit author statement

Paula Turiello: Writing - Original Draft, Methodology, Formal analysis, Writing - Review & Editing, Visualization. Claudina Vissio: Methodology, Formal analysis, Writing - Review & Editing, Visualization. Arlyn Heinrinchs: Methodology, Writing - Review & Editing. Cristina Issaly: Methodology Formal analysis Writing - Review & Editing. Alejandro Larriestra: Conceptualization, Methodology, Formal analysis, Writing - Review & Editing, Supervision

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Declaration of Competing Interest

The authors have no competing interests to declare.

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