

## PRODUCTIVITY, MILK COMPOSITION AND REASONS FOR LEAVING THE HERDS OF UKRAINIAN LOCAL COWS AND THEIR CROSSBREEDS WITH BROWN SWISS AND MONTBELIARDE BREEDS DURING FIVE LACTATIONS

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*The purpose of this work was to study changes in productivity, quality of milk, duration of productive longevity, easy calving and reasons for leaving the herd of cows of Ukrainian local Black-Spotted (UBS) (n=43) and Red-Spotted (URS) (n=46) breeds and their crossbreeds with Brown Swiss (n=28) and Montbeliarde (n=32) breeds. It was found that purebred UBS cows outnumbered crossbred UBS cows with the Brown Swiss breed by 106.46 – 262.60 kg in the period from the first to the fifth lactation and URS crossbreeds with the Montbeliarde breed by 143.89–218.39 kg. The indices of fat and protein content in the milk of crossbred UBS and Brown Swiss cows during the period of productive use were higher in comparison with purebred analogues by 0.08–0.14% and 0.08–0.15%. Hybrids of URS cows with Montbeliarde breed outnumbered purebred analogues of these indicators by 0.13–0.16% and 0.20–0.22%, respectively. After five completed lactations, the crossbreeds of UBS cows with the Brown Swiss breed were 9.20% more than purebred UBS counterparts. A similar situation was observed in the case of crossbreeds of URS cows with Montbeliarde breed, which for the same period was 8.48% more than purebred URS counterparts. In crossbreeds of UBS cows with the Brown Swiss breed, 1.34 and 0.79% fewer cases of abortion and stillbirth compared with purebred counterparts were observed. With regard to crossbred URS and Montbeliarde cows, these indicators also showed an advantage over purebred URS animals by 0.25 and 1.01%, respectively. With regard to cases of assistance during calving, the crossover of UBS breed with Brown Swiss during the five completed lactations was lower by 1.67%, and the crossbreed of URS breed with Montbeliarde by 2.43% compared to purebred analogues.*

*Key words: cows, crossbreeding, productivity, duration of productive use, Brown Swiss and Montbeliarde breeds*

## Introduction

The duration of economic use is one of the most important indicators of the efficiency of the dairy industry. Prolonged exploitation of animals allows you to organize and conduct breeding work with the herd much better. It is believed that it is economically and selectively more profitable to keep cows for a longer time. After all, the longer use of cows increases the number of calvings, and accordingly the gross milk production increases. Reducing of the productive longevity of cows has a negative influence on the effect of selection: the rate of reproduction of the herd and the intensity of turnover in general is slowed down (Dhakal et al., 2013).

The longevity of cows is to some extent determined by their genotype, which makes it possible to breed cattle for increasing the duration of economic use. Throughout modern history, milk has traditionally been obtained from purebred cows of local breeds (Kargo et al., 2012; Borshch et al., 2018). In recent decades, complex, long-term selection strategies have led to an increase in milk production by Holstein cows (Miglior et al., 2005), which now is the mainstay in most parts of the world with temperate climate.

Selection of animals by indicators of high productivity and size, negatively affected the indicators of reproduction, easy calving, calf crop and quality of milk (Shook, 2006; Heins et al., 2010; Henderson et al., 2011). The deterioration in health may also be the result of a steady increase in inbreeding (Sørensen et al., 2008; Bjelland et al., 2013). As a result, dairy producers are investigating the effectiveness of heterosis to increase the efficiency and profitability of dairy cows through calf survival rates and duration of economic use (Weigel and Barlass, 2003).

Recently, an important element in improving the genetic characteristics of dairy cattle at commercial farms is the use of interbreeding (crossbreeding) (Heins and Hansen, 2012; Heins et al., 2012). The use of crossbreeding makes it possible to use a variety of additive genetic levels between breeds to grow individuals with higher economic potential. Also due to the display of the heterosis effect, higher adaptive and stress-resistant features compared to purebred counterparts characterize crossbred cows (Pyman, 2007; Borshch et al., 2019).

The most popular dairy breeds in Ukraine are Ukrainian Black-Spotted (UBS) and Ukrainian Red-Spotted (URS). These breeds are common in all regions and climatic zones of the country. UBS breed was created by crossing black-spotted local cattle with Holstein breed. Population of UBS cows makes up 40% (or 451 thousands) of the total number cows in Ukraine. Average milk yield of cows is 6500 kg of milk per lactation with a fat content of 3.75%, protein 3.14%. Productive longevity is more than 3 lactations. URS breed was created by crossing red-spotted local cattle with Simmental and Holstein breed. Population of URS cows makes up 34% (or 394 thousands) of the total number of cows in Ukraine. Average milk yield of cows is 5700 kg of milk per lactation with a fat content of 3.71%, protein 3.23%. Productive longevity of animals is 3.25 lactations. A common problem for both breeds is the length of productive longevity.

The aim of this research was to study changes in productivity, quality of milk, duration of productive longevity, ease of calving and reasons for leaving the herd of Ukrainian local Black and Red-Spotted breeds and their crossbreeds with Brown Swiss and Montbeliarde breeds during five lactations.

## Material and methods

The research was conducted at the dairy farm “Mikhailivske”, Mikhailivka village (49°11'52" North latitude, 28°43'29" East longitude) of Vinnitsa region with the cows of the Ukrainian Black-Spotted (UBS) dairy breed and crossbred cows of the first generation obtained as a result of crossing with Brown Swiss breed and at the dairy farm “Azorel”, village Mukhivka (48°57'01" North latitude, 28°47'09" East longitude) of Vinnitsa region with the cows of the Ukrainian Red-Spotted (URS) dairy breed and crossbred cows of the first generation obtained from crossing of the URS dairy breed with Montbeliarde breed. In both farms, there were two groups of purebred and crossbred cows analogues. In the first case (farm “Mikhailivske”) the number of purebred cows was 43 and crossbred 46 head. In the second case (farm “Azorel”) the number of purebred cows was 28 and crossbred 32 head. Experiments were carried out in the period from October 2012 to June 2020.

Cases of assistance during calving, abortion of cows, stillbirths (calf dies just prior to and during parturition) of calves and the reasons for culling cows from the herd were recorded according to the results of veterinary conclusions. A veterinarian or farm staff due to the inability of the fetus to leave the animal's genitals by its own considered cases of assistance during the calving.

On both dairy farms cows were milked twice daily, between 07:00 and 09:00 h, and between 18:00 and 20:00 h (farm “Mikhailivske”). On farm “Azorel” cows were milked between 06:00 and 08:00 h, and between 16:00 and 18:00 h. The accounting of milk productivity of the experimental cows was carried out according to daily and monthly yields. Cows are milked in milking parlors “Parallel” (farm “Mikhailivske”) capacity 2x6 and “Tandem” (farm “Azorel”). Milk fat, protein, and lactose concentrations were determined weekly on two consecutive (morning and evening) milk samples (Milkotester Lactomat Rapid S, Bulgaria).

The net energy content (NEL) of milk was estimated by means of the following equation, derived from that proposed by the Nutrient Requirements of Dairy Cattle (2001):

$$NEL \text{ (Mcal/kg)} = 0.0929 \times \text{fat, \%} + 0.0547 \times \text{protein, \%} + 0.0395 \times \text{lactose, \%},$$

where *NEL* is the gross energy of one kg of milk.

The NEL values obtained were converted to MJ kg<sup>-1</sup>.

In Tables 1–3 data are presented as the means±standard error of the mean. Student's *t*-test was used to estimate statistical significance of the obtained values. Data were considered significant at  $P < 0.05$ ,  $P < 0.01$ ,  $P < 0.001$ . Student's *t*-test was performed to compare average indicators of purebred UBS and URS and average indicators of UBS × Brown Swiss and URS × Montbeliarde. These computations were performed using the STATISTICA software (Version 11.0, 2012).

Table 1. Changes in milk productivity of cows, quality composition and energy value of milk with age

Lactation	n	Milk yield per 305 days of lactation	Mass fraction of fat in milk (%)	Mass fraction of protein in milk (%)	Mass fraction of lactose in milk (%)	Energy value of 1 kg of milk (MJ)
<b>UBS</b>						
I	43	6302.81±33.29	3.74±0.03	3.03±0.02	4.54±0.04	2.897±0.031
II	40	6537.53±34.18	3.77±0.02	3.06±0.02	4.54±0.04	2.918±0.033
III	39	6682.14±33.57	3.74±0.02	3.04±0.02	4.53±0.02	2.901±0.028
IV	25	6619.47±32.09	3.73±0.03	3.04±0.01	4.52±0.03	2.893±0.024
V	11	6554.22±32.46	3.72±0.02	3.04±0.02	4.52±0.03	2.889±0.027
<b>½ UBS and ½ Brown Swiss</b>						
I	46	6196.36±28.43*	3.82±0.09	3.18±0.03***	4.56±0.03	2.964±0.030
II	46	6348.62±30.77***	3.89±0.05*	3.18±0.03**	4.56±0.03	2.994±0.033
III	42	6419.54±32.15***	3.85±0.05*	3.15±0.02***	4.53±0.02	2.964±0.027
IV	31	6472.43±34.71**	3.85±0.04*	3.15±0.02***	4.53±0.02	2.964±0.024*
V	16	6336.21±31.12***	3.86±0.05*	3.12±0.02**	4.54±0.02	2.969±0.026*
<b>URS</b>						
I	28	6478.20±38.31	3.73±0.05	3.16±0.04	4.60±0.05	2.935±0.022
II	27	6584.72±36.90	3.75±0.05	3.16±0.04	4.58±0.04	2.939±0.024
III	23	6640.35±38.43	3.75±0.04	3.17±0.05	4.58±0.04	2.939±0.023
IV	14	6672.42±38.19	3.72±0.04	3.15±0.03	4.57±0.04	2.923±0.022
V	9	6587.53±35.80	3.72±0.05	3.15±0.03	4.55±0.03	2.922±0.022
<b>½ URS and ½ Montbeliarde</b>						
I	32	6259.81±33.72***	3.89±0.06*	3.38±0.03***	4.61±0.05	3.048±0.028**
II	32	6411.33±34.54**	3.89±0.05*	3.37±0.03***	4.61±0.05	3.044±0.028**
III	32	6489.70±34.71**	3.88±0.05*	3.37±0.03	4.60±0.05	3.040±0.025**
IV	21	6528.53±35.07**	3.88±0.06*	3.36±0.05**	4.58±0.04	3.035±0.024**
V	13	6457.10±32.11**	3.88±0.05*	3.36±0.05**	4.59±0.04	3.037±0.024**

\*P&lt;0.05; \*\*P&lt;0.01; \*\*\*P&lt;0.001 as compared with UBS and UBR groups. UBS: Ukrainian Black-Spotted dairy breed, URS: Ukrainian Red-Spotted dairy breed.

## Results

According to the Table 1, we see that the productivity of cows of all groups changed with age. Purebred cows predominated in terms of productivity of crossbred analogues throughout the total period of productive use. Thus, purebred UBS cows outnumbered crossbred UBS cows with the Brown Swiss breed by 106.46–262.60 kg within the period from the first to the fifth lactation. The same trend was observed in purebred URS cows, which prevailed crossbreeds with Montbeliarde breed by 143.89 – 218.39 kg. Maximum productivity per lactation in crossbred groups of cows was during the fourth lactation. The indices of fat and protein content in the milk of crossbred UBS and Brown Swiss cows during the five lactations was higher compared to purebred counterparts by 0.08–0.14% and 0.08–0.15%. Crossovers of URS with Montbeliarde breed outnumbered purebred analogues upon these indicators by 0.13–0.16% and 0.20–0.22%, respectively. With regard to the content of lactose in milk, in UBS crossbreeds with Brown Swiss breed this indicator prevailed by 0.01–0.02% and in URS crossbreeds with Montbeliarde breed by 0.01–0.03%. The energy value of 1 kg of milk directly depends on its quality composition. In UBS crossbreeds with Brown Swiss breed, the energy value of 1 kg of milk during five lactations was higher by 0.063–0.080 MJ compared to purebred UBS counterparts and in URS crossbreeds with Montbeliarde breed by 0.101–0.115 MJ, respectively.

One of the main indicators that characterize the productive and adaptive characteristics of dairy cows is their lifetime. Upon that, the age of the first calving in purebred UBS cows was 11 days, and in red-spotted cows, 3 days earlier than in crossbred counterparts. The average milk yield for five lactations in UBS crossbreeds was 1395.54 kg higher than in purebred UBS cows. In red-spotted crossbreeds with Montbeliarde breed, this figure prevailed by 3256.92 kg compared with purebred URS cows (Table 2). In UBS crossbreeds with Brown Swiss breed, length of productive life was longer by 195 days compared to purebred UBS counterparts and in URS crossbreeds with Montbeliarde breed by 312 days, respectively. According to the amount of synthesized fat, protein and lactose during five lactations, which characterize the nutritional characteristics of milk and the suitability for processing a crossover of UBS cows with the Brown Swiss breed, purebred analogues prevailed by 80.12; 70.35 and 65.76 kg, respectively. In URS crossbreeds with Montbeliarde, the synthesis of fat, protein and lactose dominated purebred URS analogues by: 162.02, 155.97 and 156.44 kg, respectively. Accordingly, higher values of crossbred cows were also according to the indices of energy value of milk: 5873.51 MJ in UBS with Brown Swiss breed and 12314.89 MJ in URS with Montbeliarde breed.

The indices of the table show that crossbred cows had lower culling rates during five completed lactations (Table 3). The number of crossbred UBS cows with the Brown Swiss breed was 9.21% more (from the initial size of the group) than purebred UBS cows. The number of crossbreeds between URS and Montbeliarde was 8.50% more (of the original group size) than URS purebred cows. Regarding the duration of open days, in the crossbred UBS and Brown Swiss cows after the first three lactations values of this indicator were higher than those of purebred counterparts.

Table 2. Average milk yield, quality composition of milk and its energy value for five lactations

Indicators	Breed			
	UBS	½ UBS and ½ Brown Swiss	URS	½ URS and ½ Montbeliarde
Age of the first calving, days	817±9.54	828±10.27	844±11.32	847±11.56
Length of productive life, days (as of 5 completed lactations)	1048±243.2	1243±219.5	1086±249.6	1398±190.5
Average milk yield for five lactations (kg)	23991.15±409.47	25386.69±523.34**	22081.05±535.49	25337.97±641.52***
Synthesized milk fat for five lactations (kg)	897.26±22.57	977.38±24.21*	823.62±24.30	985.64±27.19***
Synthesized milk protein for five lactations (kg)	729.33±12.63	799.68±15.87***	697.31±10.28	853.28±14.31***
Synthesized lactose for five lactations (kg)	1086.79±16.61	1152.55±24.22*	1009.10±23.29	1165.54±27.35***
The average energy value of milk for five lactations (MJ)	69550.34±1638.55	75423.85±1973.27*	64732.80±1586.46	77047.69±2029.38***

\*P<0.05; \*\*P<0.01; \*\*\*P<0.001 as compared with UBS and UBR groups. UBS: Ukrainian Black-Spotted dairy breed, URS: Ukrainian Red-Spotted dairy breed.

However, after the fourth and fifth lactations, lower values of the duration of open days were observed. In crossbreds of URS cows with Montbeliarde, the duration of open days was slightly lower (6 to 23 days) during five lactations.

Table 3. Duration of open days, cases of abortions, stillbirths and severity of calving in cows during five lactations

Lactation	n	% of cows that were culled before starting subsequent lactations	Open days	Cases of abortions and stillbirths	Cases of assistance during calving
<b>UBS</b>					
I	43	–	134±6.5	2	3
II	40	6.98	117±4.7*	3	2
III	39	9.30	128±6.2	1	–
IV	25	41.86	112±5.6	–	1
V	11	74.42	118±8.3	–	1
Average open days and total numbers (and %) of stillbirths and difficult calvings	–	–	121.8±4.1	6 (13.95)	7 (16.27)
<b>½ UBS and ½ Brown Swiss</b>					
I	46	–	143±8.3	–	3
II	46	–	125±6.1	2	1
III	42	4.34	131±5.9	–	1
IV	31	32.60	109±7.3*	1	1
V	16	65.21	105±8.1	–	–
Average open days and total numbers (and %) of stillbirths and difficult calvings	–	–	123.2±7.4	3 (6.52)	6 (13.04)
<b>URS</b>					
I	28	–	139±7.4	–	2
II	27	3.57	148±8.0	1	1
III	23	17.85	136±5.5	–	1
IV	14	50.00	117±5.1*	1	–
V	9	67.86	109±5.8	–	–
Average open days and total numbers (and %) of stillbirths and difficult calvings	–	–	129.8±7.24	2 (7.14)	4 (14.28)
<b>½ URS and ½ Montbeliarde</b>					
I	32	–	128±6.7	–	1
II	32	–	135±6.1	–	1
III	32	–	129±5.4	1	–
IV	21	34.37	102±6.0**	–	–
V	13	59.37	106±5.8	–	–
Average open days and total numbers (and %) of stillbirths and difficult calvings	–	–	120.0±6.6	1 (3.12)	2 (6.25)

\*P<0.05; \*\*P<0.01 as compared with the previous lactation

In crossbreeds of UBS cows with the Brown Swiss breed 7.43% fewer cases of abortion and stillbirth were observed compared with purebred UBS counterparts during five lactations. With regard to crossbred URS and Montbeliarde cows, these indicators also showed an advantage over purebred URS animals by 4.02%, respectively. With regard to cases of assistance during calving, the hybrids of UBS breed with Brown Swiss cows during the five completed lactations was lower by 3.23%, and the crossbreed of URS breed with Montbeliarde by 8.03% compared to purebred analogues.

Table 4. Reasons for cows' culling from the herd during five lactations

Lactation	n	Breed			
		Postpartum and gynecological diseases	Diseases of an udder	Diseases and injuries of extremities	Diseases of the digestive system
<b>UBS</b>					
I	43	2	–	1	–
II	40	1	–	–	–
III	39	7	2	4	1
IV	25	8	1	5	–
V	11	1	–	1	–
Sum (and %) of cows culled due to 4 different reasons	–	19 (44.18)	3 (6.97)	11 (25.58)	1 (2.32)
<b>½ UBS and ½ Brown Swiss</b>					
I	46	–	–	–	–
II	46	2	–	2	–
III	42	6	1	3	1
IV	31	8	2	3	–
V	18	2	–	–	–
Sum (and %) of cows culled due to 4 different reasons	–	18 (39.13)	3 (6.52)	8 (17.39)	1 (2.17)
<b>URS</b>					
I	28	1	–	–	–
II	27	2	2	–	–
III	23	4	2	2	1
IV	14	3	1	1	–
V	9	1	–	1	–
Sum (and %) of cows culled due to 4 different reasons	28	11 (39.28)	5 (17.85)	4 (14.28)	1 (3.57)
<b>½ URS and ½ Montbeliarde</b>					
I	32	–	–	–	–
II	32	–	–	–	–
III	32	8	2	1	–
IV	21	4	3	–	–
V	14	1	–	–	–
Sum (and %) of cows culled due to 4 different reasons	32	13 (40.62)	5 (15.62)	1 (3.12)	–



Crossbred cows had lower culling rates after all diseases compared to purebred counterparts (Table 4). Postpartum and gynecological diseases in cows have a direct impact on the duration of their productive longevity, the health of reproductive function and the amount of produced milk. In all research groups, postpartum and gynecological diseases were the largest indicator among the reasons for the departure of cows from the herd. In crossbred UBS and Brown Swiss cows 5.67%, fewer cases of cows due to postpartum and gynecological diseases were observed compared to purebred counterparts. However, in crossbred URS and Montbeliarde cows, the incidence of postpartum and gynecological diseases was 1.34% higher than in purebred counterparts. Inflammatory processes in the udder of cows affect the reduction of productivity and significant changes in the quality of milk. Among UBS crossbreeds with the Brown Swiss breed there were 0.45% fewer cases of cows leaving due to udder diseases, while among red-spotted crossbreeds with the Montbeliarde breed, this value was 2.23% compared to purebred counterparts. Diseases and injuries of the extremities are a common problem in highly productive herds of Holstein cows (Miglior et al., 2005). They have a significant effect on the profitability of milk production. The rates of culling cows leaving the herd due to diseases and injuries of the extremities in the crossbreeds of UBS with Brown Swiss and URS with Montbeliarde breeds were 8.19 and 11.16% lower, respectively, compared to purebred counterparts. Digestive diseases in dairy cows occupy first place among non-communicable diseases and very often are the reasons for culling of animals. As for the reasons for the departure of cows from the herd due to diseases of the digestive system, in UBS crossbreeds with the Brown Swiss breed this figure was 0.15% lower than in purebred counterparts. In the crossbred cows of URS with Montbeliarde breeds, no cases of cows leaving the herd due to digestive diseases were observed during five lactations. In the group of purebred URS cows, 3.57% of cows left the herd during five lactations due to diseases of the digestive system.

## Discussion

Reducing the life expectancy of dairy cattle in the late 20th century was recognized as one of the greatest problems in dairy farming (Harris et al., 1996). Dairy longevity is a complex quantitative indicator that influences the milk production, fertility, and animal health (Roxstrom and Strandberg, 2002; Del Schneider et al., 2003). Longer life expectancy of cows reduces the cost of turnover (replacement) of the herd, increases the number of young animals for sale and increases the part of highly productive animals in the herd. Renkema and Stelwagen (1979) report that prolonging of the productive use of cows from three to four lactations increases annual profits through milking and calving by 11–13%. One of the factors that partially resolve the problem of low life expectancy of cows is the use of crossbreeding at industrial farms (Freyer et al., 2008). However, the problem of the influence of crossing on the productivity and composition of milk during the productive period, the ease of calving, the number of open days on Ukrainian local breeds have not been conceptually studied yet. These indicators depend on both the climatic features of the region and the local breed composition, which has evolved in a given area (Upadhyay et al., 2017).

Our results partially coincide with the results of Effa et al. (2013), which report an increase in pre-aged milk yield in first-generation (F<sub>1</sub>) crossbreeds obtained by crossing Friesian and Jersey cows with local Ethiopian cattle of Boran breed. However, Hazel et al. (2014) indicate that there is no significant difference in fat + protein results during five lactations in purebred Holstein cows and Holstein crossbreeds with Montbeliarde breed, which does not coincide with the results obtained in our studies. Hazel et al. (2021) reported that 2-breed crossbreeds (376 Viking Red × Holstein and 358 Montbeliarde × Holstein) had +158 days longer herd life and the 3-breed crossbreeds (109 Viking Red × Montbeliarde / Holstein and 117 Montbeliarde × Viking Red/Holstein) had +147 days longer herd life compared with their respective Holstein herdmates. These data partially coincide with the results of our research.

The results of our research on the duration of productive use of local Ukrainian black and red-spotted breeds and their crossbreeds with Brown Swiss and Montbeliarde breeds coincide with the data of Danish scientists (Clasen et al., 2017). This paper reports about the increase in life expectancy and productive use in crossbred cows obtained by crossing Danish Holsteins, Red Danish and Danish Jerseys, compared with purebred Danish Holsteins (Clasen et al., 2017). Effa et al. (2013) in their studies conducted in Ethiopia with local cattle of the Boran breed and its crossbreeds with the Friesian and Jersey breeds, also report about longer duration of productive use of crossbreeds compared to purebred animals.

The results of our studies partially coincide with the data of Hazel et al. (2014), which indicate higher survival rates of calves obtained as the result of crossbreeding of Montbeliarde and Holstein breeds cows and from Montbeliarde and ½ Jersey x ½ Holstein breeds, compared with purebred Holsteins. In addition, the cows of crossover groups had higher rates of easy calving.

The influence of crossbreeding on the ease of calving, abortion and stillborn calves has been reported by Dhakal et al. (2013), who underline a positive effect according to these indices at local Holstein × Jersey cows compared to purebred Holsteins. Khair et al. (2013) in their researches conducted in Bangladesh using local highland cows and their hybrids with Holsteins, indicate a decrease in abortions after the first calving in crossbred cows, compared with purebred ones, which also coincides with our results. Hazel et al. (2020), in their researches (conducted in 7 commercial dairy herds in Minnesota, USA) indicate that stillbirth rate for calves born to 2-breed (Red Viking × Holstein and Montbeliarde × Holstein) crossbred dams (4%) was significantly lower compared with calves born to purebred counterparts (Holstein) herdmates (8%) at first calving. These data partially coincide with our results.

## Conclusions

It has been found out that purebred black-spotted and red-spotted cows surpassed local counterparts in terms of milk yield during the five completed lactations. The average content of fat, protein, lactose and, accordingly, the energy value of milk prevailed in crossbreeds of UBS and Brown Swiss breeds compared with purebred black-spotted counterparts and in URS crossbreeds with Montbeliarde breed compared to purebred red-spotted cows. In addition, fewer cases of stillbirths, abortions, and assistance during calving were observed in crossbred cows.

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