RESEARCH ARTICLE

Calf, Dam and Sire Factors Affect Birth Weight of Gir Calves

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Abstract

Birth weight data of Gir calves (n = 1116) spread over 9 years (2011-2019) were used to assess the influence of calf, dam, and sire factors on the birth weight of calves. Various calf factors, *viz.,* period, month, season, and sex of calf; dam factors, *viz.,* age, parity and gestation period and sire factors of Gir cattle were considered for the study. The overall mean birth weight of Gir calves was 22.29 ± 0.10 kg. There was a significant effect of the period ($p \leq 0.05$), month ($p \leq 0.05$), and season ($p \leq 0.05$) of calving on calf birth weight. The weight of Gir calves at birth was lower during the rainy season and higher during the winter season ($p \leq 0.05$). Male calves had 10 % (2.2 kg) higher birth weight than their female counterparts ($p \leq 0.05$). There was a significant effect of age ($p \leq 0.05$) and parity ($p \leq 0.05$) of a dam on calf birth weight. The gestation period also had a significant ($p \leq 0.05$) effect on birth weight. The birth weight was significantly ($p \leq 0.05$) influenced by the service sire. The heritability estimate was 0.132 for the birth weight of Gir calves, which indicated low heritability. The results showed that calf, dam, and sire factors markedly influenced birth weight, and better managemental interventions during the last trimester of pregnancy could improve the birth weight of calves in Gir cattle.

Keywords: Birth weight, Calf factors, Dam factors, Gir cattle, Sire factors.

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Introduction

Gir is one of the important dairy type Indian zebu cattle, native to the Saurashtra region of Gujarat. Few Gir animals are also found in the other parts of India, particularly Rajasthan, Madhya Pradesh, and Maharashtra. This breed has huge production potential, and it sustains her productivity in a hot climate. The gir breed also has inherent resistance to tropical diseases (Patbandha *et al.,* 2020). However, the weight of calves at birth plays a significant role in their survival, health, and welfare. The survival rate of calves with lower birth weight is less, whereas the calves with higher birth weight increased the risk of calving difficulty (Upadhyay *et al.,* 2017). This may further negatively affect dam's health, productivity, and reproductive performance. Hence, in a breeding program, the calf birth weight is considered one of the important traits that act as an indicator of prenatal growth and post-natal growth and development (Wakchaure and Meena, 2010). The birth weight also affects the other future traits like puberty, sexual maturity, age at first calving, and subsequent productivity of the female calves (Selvan *et al.,* 2018). There are several genetic and non-genic factors that significantly affect the weight of calves at birth (Wakchaure and Meena, 2010; Upadhyay *et al.,* 2017; Selvan *et al.,* 2018). Although there are few reports regarding the effect of genetic, non-genetic, and calf sex on the birth weight of Indian zebu cattle, particularly Sahiwal and Tharparkar breeds, such information is scanty in Gir cattle. Therefore, the present study was planned to evaluate the effect of calf, dam, and sire factors on the birth weight of Gir calves in an organized dairy herd.

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Materials and Methods

Data Collection and Study Area

The data pertaining to the present study were collected from Cattle Breeding Farm, Junagadh Agricultural University, Junagadh (Gujarat), India. The Cattle Breeding Farm is the largest and oldest organized farm of Gir cattle and Jaffrabadi buffaloes. This farm is located at 70.5° east longitude, 21.4° north latitude, and about 60 meters above mean sea level (Anonymous, 2020). The climate of the area is tropical to sub-tropical and meteorological variables (temperature, relative humidity, rainfall, wind speed, and sunshine) are presented in Table 1. The main aim of the farm is to maintain and improve pure Gir herd through the progeny testing program under All India Co-ordinate Research Project (AICRP). The birth weight data of Gir calf spreaded over nine years (2011-2019)

Table 1: Mean weather variables during 2011-2019.

Months	*Temperature (°C)*	*Relative humidity (%)*	*Rainfall (mm)*	*Wind speed (km/hour)*	*Sunshine (hour)*
January	20.61 ± 0.27	48.93 ± 1.70	0.00 ± 0.00	4.29 ± 0.25	8.16 ± 0.25
February	23.43 ± 0.34	46.18 ± 2.03	0.00 ± 0.00	4.67 ± 0.17	8.61 ± 0.26
March	27.63 ± 0.33	42.53 ± 2.09	0.11 ± 0.09	5.38 ± 0.07	9.56 ± 0.15
April	30.97 ± 0.23	47.39 ± 0.98	0.02 ± 0.02	6.37 ± 0.20	9.75 ± 0.15
May	32.64 ± 0.21	56.99 ± 0.98	0.00 ± 0.00	8.75 ± 0.26	9.57 ± 0.29
June	31.51 ± 0.23	68.47 ± 1.21	5.46 ± 1.79	10.28 ± 0.56	3.76 ± 0.46
July	28.74 ± 0.32	82.18 ± 1.46	10.29 ± 1.64	8.73 ± 0.44	0.85 ± 0.26
August	27.83 ± 0.17	84.32 ± 1.31	7.27 ± 1.51	6.65 ± 0.58	1.39 ± 0.30
September	28.04 ± 0.16	78.00 ± 1.68	8.85 ± 2.11	4.28 ± 0.36	4.82 ± 0.45
October	28.91 ± 0.30	57.75 ± 2.72	1.10 ± 0.58	2.75 ± 0.26	8.36 ± 0.34
November	25.87 ± 0.38	51.16 ± 2.08	0.17 ± 0.13	2.80 ± 0.20	8.22 ± 0.29
December	22.23 ± 0.29	49.60 ± 1.32	0.01 ± 0.01	3.79 ± 0.18	7.56 ± 0.49

were collected from the birth register. Records of normal full-term birth and normal calves (n = 1116; 549 males and 567 females) were included for the study. Information related to calves such as date of birth, sex and weight, and informations related to their dam (age, parity, gestation period) and sire (sire number/ name) were also included for the study.

Data Classification and Statistical Analysis

The birth weight data was checked for normal distribution, and the out layers (mean ± 3SD), *i.e.*, extreme values, were excluded. Then the birth weight was classified based on age of dam into five classes (≤4 years, 5-6 years, 7-8 years, 9-10 years, and >10 years); parity of dam into nine classes (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th}, 7^{th}, 8^{th}, and $\geq 9^{th}$); gestation period into three classes (<275 days, 275-290 days and >290 days); service sire into 26 classes (1-26); period of birth into nine classes (P1:2011, P2:2012, P3:2013, P4:2014, P5:2015, P6:2016, P7:2017, P8:2018 and P9:2019); and a month into 12 classes (January to December). Keeping in view the climatological data (Table 1), the season was classified into three classes (Winter: Nov-Feb, Summer: Mar-Jun and Rainy: Jul-Oct) and calf sex into two classes (male and female). Effect of age, parity, gestation period, service sire, month, season, and sex on birth weight was analyzed by GLM procedure of SPSS software version 16. The effect was considered as significant if $p \leq 0.05$. The DMRT posthoc test was used to compare the pair-wise mean difference between two groups and considered significant at 5%. Pearson's correlation analysis calculated the association between gestation period and birth weight. Intra-class correlation among half-sib method was used to estimate the heritability of birth weight (Thomas *et al.,* 2012).

Results and Discussion

Birth Weight

Overall mean birth weight of Gir Calves was 22.29±0.10 kg (standard deviation = 3.39 kg), which is comparatively lower than the previous studies (23.7-23.8 kg; Mayekar *et al.,* 2017; Patbandha *et al.,* 2020) on the same breed. Birth weight variation among different studies on the same breed may be due to the prevailing managemental practices among different farms across different time periods. The birth weight of Gir calf is slightly higher than the Sahiwal calves (19.92-21.47 kg; Wakchaure and Meena, 2010, Manoj *et al.,* 2014b, Selvan *et al.,* 2018) and Tharparkar calves (20.91 kg; Selvan *et al.,* 2018). This indicates that among the Indian dairy breeds, Gir calves have higher birth weight may be due to their genetic makeup. Although the birth weight of Gir calves was comparatively higher than the crossbred triple crossbred calves of Kankrej x HF x Jersey (22.09 kg; Dhami *et al.,* 2006) and Vrindavani cattle (21.92 kg; Upadhyay *et al.,* 2017), it was lower than the crossbred calves like Karan-Swiss (26.74-28.03 kg; Mandal and Sachdeva, 1999), Frieswal (26.93 kg; Kumar *et al.,* 2008) and Karan-Fries (28.29; Selvan *et al.,* 2018). The higher birth weight in crossbred calves may be due to exotic inheritance (37.5-67.5 %) as the exotic taurine cattle have a higher weight and capacious body cavity than Indian zebu cattle. The managerial practices followed in different farms or herds might be attributed to alteration of birth weight as the birth weight has low heritability and same being observed in the present study.

Effect of Calf Factors on Birth Weight

Period of Calving

There was a significant ($p \leq 0.05$) effect of a period of calving on the birth weight of Gir calves. The birth weight was lower during the year 2012 but higher during the year 2018 (Table 2, $p \leq 0.05$). In a similar line, a significant effect of a period of calving on the birth weight in zebu cattle like Sahiwal (Wakchaure and Meena, 2010; Manoj *et al.,* 2014b) and Tharparkar (Selvan *et al.,* 2018), as well as crossbred cattle (Kumar *et al.,* 2008; Raja *et al.,* 2010; Selvan *et al.,* 2018), has been cited in different studies. Contrary to the present study, Selvan *et al.* (2018) observed a non-significant effect of the

calving period on this trait in Sahiwal cattle. The variation of meteorological variables such as ambient temperature, relative humidity, precipitation, wind velocity, sunshine, etc. of a particular region across different periods, including the managemental practices adopted during the last trimester of pregnancy, may cause alteration in birth weight during different periods (Raja *et al.,* 2010).

Month and Season of Calving

Birth weight was significantly ($p \leq 0.05$) influenced by the month of calving, where the lowest birth weight was observed during August-September and highest during December months (Table 2, $p \leq 0.05$). Information regarding the effect of calving months on birth weight is scanty, but most studies recorded season effect on birth weight. The hot-humid environment during the last two months of gestation may have a negative effect on birth weight as, during this period, about 60% fetal growth occurs (Tao and Dahl, 2013). Similar to month of birth, season of birth had a significant ($p \leq 0.05$) effect on the weight of Gir calves at birth. The birth weight was highest during winter and lowest during rainy seasons (Table 2, $p \leq 0.05$). Our results are in consonance with previous studies (Wakchaure and Meena, 2010; Manoj *et al.,* 2014b; Selvan *et al.,* 2018) conducted on Sahiwal cattle, who observed highest and lowest birth weight during winter and rainy season, respectively. Upadhyay *et al.* (2017) observed lower birth weight during the rainy (hot-humid) season in crossbred calves, which is supported by our results. But, they observed the highest birth weight during the summer (hot-dry) season, contrary to the present finding. However, Raja *et al.* (2010) did not observe any seasonal effect on the weight of crossbred calves at birth. The lower birth weight during the hot-humid (rainy) season as compared to winter indicates that late summer and early rainy season are more stressful for the advanced pregnant Gir cattle. Heat stress increases cutaneous circulation and reduction of blood flow to the uterus and placental growth in dairy cattle. This leads to fetal hypoxia and malnutrition of growing fetuses during the last trimester of pregnancy, resulting in lower weight of calves at birth (Tao and Dahl, 2013).

Table 2: Effect of calf factors on birth weight (n=1116)

Effect of period of calving:		
Period	*No. of Records*	*Mean ± SE*
2011	101	$22.11^{b} \pm 0.33$
2012	106	$20.33^{a} \pm 0.32$
2013	86	$20.71^{a} \pm 0.35$
2014	144	$22.45^{bc} \pm 0.27$
2015	125	$23.20^{c} \pm 0.29$
2016	172	$22.42^{bc} \pm 0.25$
2017	147	$23.15^{c} \pm 0.27$
2018	105	$23.21^{c} \pm 0.32$
2019	130	$22.13^{b} \pm 0.29$
Effect of the month of birth:		
January	118	$22.45^{abcd} \pm 0.31$
February	86	$22.89^{cd} \pm 0.36$
March	99	$22.01^{abcd} \pm 0.34$
April	94	$22.82^{bcd} \pm 0.35$
May	100	$22.68^{bcd} \pm 0.34$
June	85	$21.83^{abc} \pm 0.37$
July	69	$22.13^{abcd} \pm 0.41$
August	97	$21.71^{ab} \pm 0.34$
September	97	$21.46^{a} \pm 0.34$
October	103	$22.27^{abcd} \pm 0.33$
November	67	$22.06^{abcd} \pm 0.41$
December	101	$23.02^{d} \pm 0.34$
Effect of season of calving:		
Winter (Nov-Feb)	372	$22.64^{b} \pm 0.18$
Summer (Mar-Jun)	378	$22.35^{ab} \pm 0.17$
Rainy (Jul-Oct)	366	$21.88^{a} \pm 0.18$
Means with different superscripts differ significantly ($p \leq 0.05$)		

Sex of Calf

Sex of calf had significant ($p \leq 0.05$) effect on the birth weight of Gir calf. Male Gir calves had 2.2 kg (10 %) higher birth weight than female calves (23.40±0.14 *vs.* 21.21±0.14 kg). Several studies also cited higher birth weight in male calves as compared to their female counterparts (Raja *et al.,* 2010; Manoj *et al.,* 2014a; Upadhyay *et al.,* 2017; Selvan *et al.,* 2018). Manoj *et al.* (2014b) reported that male Sahiwal calves were 1.64 kg (7.95 %) heavier than their female counterparts. In a recent study, it has been observed that male Sahiwal, Tharparkar, and crossbred Karan Fries calves had 1.21 (5.89 %), 1.45 (6.71 %), and 1.15 (3.98 %) kg, respectively, higher birth weight than female calves (Selvan *et al.,* 2018). The higher birth weight in male calves may be due to the higher circulating androgen in the male fetus, affecting fetal growth (Upadhyay *et al.,* 2017). The male to female sex ratio in Gir calves was 49:51. Upadhyay *et al.* (2017) observed a sex ratio of 51:49 in crossbred Vrindavani cattle. Moreover, the sex ratio of Gir calves is close to the normal expected sex ratio of 50:50 in dairy cattle.

Effect of Dam Factors on Birth Weight

Age and Parity of Dam

There was a significant effect of age of dams ($p \leq 0.05$) and parity ($p \leq 0.05$) on calves' birth weight. Dams with age below or up to 4 years delivered calves of lower birth weight, whereas dams between 9-10 years of age delivered calves of higher birth weight (Table 3, $p \leq 0.05$). Upadhyay *et al.* (2017) observed an increasing trend of calf birth weight with the advancement of age which is also supported by our result. The birth weight of calves born from 4th and 7th parity cows

had higher and lower weight, respectively (Table 3, p ≤ 0.05). The calves' weight increased gradually from 1st to 4th parity of dam but did not differ statistically. Previous studies also cited the gradual increase in birth weight of calves with an increase in parity of dams from 1st to 4th in both zebu (Selvan *et al.,* 2018) and crossbred (Raja *et al.,* 2010; Selvan *et al.,* 2018) cattle. However, Upadhyay *et al.* (2017) did not observe the parity effect on the birth weight of crossbred calves. The gradual increase in calf weight with an increase in parity of dam might be attributed to an increase in weight of dam along with intra-uterine space. Poncheki *et al.* (2015) reported that dam achieved about 82, 92, and 100% of her adult body weight at 1st, 2nd, and 3rd calving, respectively. This indicates a gradual increase in dams' weight with the advancement of parity in dairy cattle. However, after 4th parity, there was a fluctuation in body weight, which is in accordance with other studies (Raja *et al.,* 2010; Selvan *et al.,* 2018).

Gestation Period of Dam

The gestation period significantly (p ≤ 0.05) affected the birth weight of Gir calves. The calf's birth weight gradually and significantly (p ≤ 0.05) increased with an increase in gestation period (Table 3). This indicates the linear relationship of gestation length with birth weight in Gir calves which is in agreement with the reports on zebu cattle (Selvan *et al.,* 2018), taurine cattle (Atashi and Asaadi, 2019), and crossbred cattle (Raja *et al.,* 2010; Upadhyay *et al.,* 2017; Selvan *et al.,* 2018). Further, a correlation study revealed a significant and positive correction (r = 0.327, p <0.001) between gestation period and birth weight in Gir cattle. In general, 60% of fetal growth occurs during the last two months of pregnancy, and even the growth is 300 to 400 g/day during the last month of pregnancy (Tao and Dahl, 2013; Atashi and Asaadi, 2019). This may be the reason for higher birth weight in calves born from dam having more extended gestation period.

Table 3: Effect of dam factors on calf birth weight (n = 1116)

Effect of age of dam at calving:		
Age of dam	*No. of Records*	*Mean ± SE*
≤ 4 years	290	$21.80^{a} \pm 0.20$
5-6 years	347	$22.23^{ab} \pm 0.18$
7-8 years	237	$22.66^{bc} \pm 0.22$
9-10 years	124	$23.00^{c} \pm 0.30$
> 10 years	118	$22.19^{ab} \pm 0.31$
Effect of parity of dam		
Parity of dam	*No. of Records*	*Mean ± SE*
1st	350	$21.80^{ab} \pm 0.18$
2nd	266	$22.40^{ab} \pm 0.21$
3rd	187	$22.60^{ab} \pm 0.25$
4th	127	$22.99^{b} \pm 0.30$
5th	81	$22.57^{ab} \pm 0.38$
6th	46	$22.72^{b} \pm 0.50$
7th	26	$20.99^{a} \pm 0.66$
8th	15	$22.51^{ab} \pm 0.87$
≥ 9th	18	$21.38^{ab} \pm 0.80$
Effect of gestation period of dam:		
Gestation Period	*No. of Records*	*Mean ± SE*
< 275 days	88	$19.22^{a} \pm 0.35$
275-290 days	887	$22.38^{b} \pm 0.11$
> 290 days	141	$23.67^{c} \pm 0.27$

Means with different superscripts differ significantly (p ≤ 0.05)

Effect of Sire Factors on Birth Weight

Service Sire

The birth weight of Gir calf was significantly (p ≤ 0.05) affected by the service sire. Several authors observed a significant sire effect on the birth weight of calves (Raja *et al.,* 2010; Upadhyay *et al.,* 2017; Selvan *et al.,* 2018) which is supported by our result. Calves born from sire number 12 had lower (19.91 kg) birth weight, whereas calves from sire number 18 had higher (25.05 kg) birth weight (Table 4, p ≤ 0.05). There

Table 4: Effect of service sire on calf birth weight (n = 1116)

Service sire	*No. of Records*	*Mean ± SE*
1	35	$22.02^{bcde} \pm 0.56$
2	22	$22.06^{bcde} \pm 0.71$
3	23	$22.85^{cde} \pm 0.70$
4	37	$21.18^{abcd} \pm 0.55$
5	60	$21.97^{bcde} \pm 0.43$
6	28	$23.83^{ef} \pm 0.63$
7	43	$22.84^{cde} \pm 0.51$
8	43	$23.05^{de} \pm 0.51$
9	30	$23.12^{de} \pm 0.61$
10	43	$22.14^{bcde} \pm 0.51$
11	49	$23.21^{de} \pm 0.48$
12	29	$19.91^{a} \pm 0.62$
13	39	$20.67^{ab} \pm 0.53$
14	63	$22.48b^{cde} \pm 0.42$
15	48	$22.44^{bcde} \pm 0.48$
16	154	$22.02^{bcde} \pm 0.27$
17	10	$20.87^{abc} \pm 1.06$
18	17	$25.05^{f} \pm 0.81$
19	81	$22.48^{bcde} \pm 0.37$
20	19	$21.13^{abcd} \pm 0.77$
21	18	$22.34^{bcde} \pm 0.79$
22	16	$21.32^{abcd} \pm 0.83$
23	10	$22.04^{bcde} \pm 1.06$
24	53	$22.35^{bcde} \pm 0.46$
25	103	$22.52^{bcde} \pm 0.33$
26	43	$22.76^{bcde} \pm 0.51$

Means with different superscripts differ significantly (p ≤ 0.05)

was a 5.41 kg mean difference in birth weight between the two extreme sires, which is more or less comparable to Upadhyay *et al.* (2017), who observed the mean difference of birth weight between two extreme sires 4.67 kg in Vrindavani crossbred cattle.

Heritability Estimate

The heritability estimate for the birth weight of Gir calves was low (h^2 = 0.132). Similarly, lower heritability estimates were cited for birth weight of Indigenous Sahiwal calves (h^2 = 0.131 and 0.149) by Manoj *et al.* (2014a) and Selvan *et al.* (2018) and for crossbred Vrindavani calves (h^2 = 0.139) by Sagar *et al.* (2017). However, other studies reported comparatively higher heritability for birth weight in Sahiwal (h^2 = 0.20 by Wakchaure and Meena, 2010), Frieswal (h^2 = 0.21; Kumar *et al.,* 2008), Karan Swiss (h^2 = 0.29 by Mandal and Sachdeva, 2009), Vrindavani (h^2 = 0.24 by Upadhyay *et al.,* 2017) and Karan Fries (h^2 = 0.32 by Selvan *et al.,* 2018) cattle. A low heritability estimate for birth weight indicated that selection has little role in improving birth weight in Gir calves. On the other hand, environmental factors play a major role in this trait's phenotypic variation. In a recent study, Sharma (2020) reported that managemental interventions, *i.e.,* challenge feeding, significantly improved the birth weight of Gir calves by 2.25 kg.

Conclusion

The overall mean birth weight of 1116 Gir calves was 22.29 ± 0.10 kg. The results indicate significant effects of the dam (age, parity, and gestation period), calf (period, month, season of calving and calf sex), and sire (service sire) factors on the birth weight of Gir calves. The heritability estimate of birth weight was low (h^2 = 0.132), which indicated a little role of selection for the improvement of the weight of calves at birth. Thus better management interventions could improve the birth weight of Gir calves in an organized farm.

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References

Anonymous (2020). Annual Progress Report-2019. Cattle Breeding Farm, Junagadh Agricultural University, Junagadh, Gujarat. 16th Meeting of AGRESCO Sub-committee on Animal Science and AH and Fisheries Science, February 17-18, 2020. pp. 1-50.

Atashi, H., & Asaadi, A. (2019). Association between gestation length and lactation performance, lactation curve, calf birth weight and dystocia in Holstein dairy cows in Iran. *Animal Reproduction, 16*, 846-852.

Dhami, A.J., Parmar, B.C., Trivedi, M.M., Arya, J.S., & Patel, J.M. (2006). Growth, production, and reproduction performance of triple bred (Kankrej x HF x Jersey) cattle in Gujarat. *International Journal of Cow Science, 2*(1), 37-39.

Kumar, S., Singh, Y.P., & Kumar, D. (2008). Genetic studies on performance traits in Frieswal cattle. *Indian Journal of Animal Sciences, 78*(1), 107-110.

Mandal, A., & Sachdeva, G.K. (1999). Genetic analysis of birth weight of calves in cattle. *Indian Journal of Animal Sciences, 69*(11), 979-980.

Manoj, M., Gandhi, R.S., Raja, T.V., Verma, A., Singh, A., Sachdeva, G.K., & Kumar, A. (2014a). Genetic parameters of body weights at different ages in Sahiwal heifers. *Indian Journal of Animal Research, 48*(3), 217-220.

Manoj, M., Gandhi, R.S., & Raja, T.V. (2014b). Effect of sex and non-genetic factors on birth weight of Sahiwal calves. *Indian Journal of Animal Sciences, 84*(8), 911-912.

Mayekar, A.J., Yadav, D.N., Kumar, S., Desai, B.G., Burte, R.G., & Dhekale, J.S. (2017). Evaluation of reproduction performance of Gir cattle (*Bos indicus*) reared in hot-humid condition of Konkan region. *Journal of Livestock Diversity, 7*(2), 93-98.

Patbandha, T.K., Sabapara, G.P., Savaliya, B.D., Dash, S.K., Parikh, S.S., & Ali, M. (2020). Physical characteristics and production performance of Gir cattle in India. *International Journal of Livestock Research, 10*, 1-11.

Poncheki, J.K., Canha, M.L.S., Viechnieski, S.L., & de Almeida, R. (2015). Analysis of daily body weight of dairy cows in early lactation and associations with productive and reproductive performance. *Revista Brasileira de Zootecnia, 44*, 187-192.

Raja, T.V., Venkatachalapathy, R.T., & Kannan, A. (2010). Estimates of genetic and phenotypic parameters on birth weight of crossbred cattle raised under organized farm conditions. *Journal of Animal and Veterinary Advances, 9*(17), 2275-2278.

Sagar, N.G., Baranwal, A., Saini, B.L., Kumar, S., & Prasad, A.R. (2017). Effect of non-genetic factors on the growth traits of Vrindavani cattle. *International Journal of Livestock Research, 7*(7), 224-230.

Sharma, M.P. (2020). Effect of challenge feeding on production performance of Gir cows. *M.V.Sc. Thesis,* Junagadh Agricultural University, Junagadh, Gujarat, India.

Selvan, A.S., Tantia, M.S., Kumaresan, A., Kumar, A., Ravi Kumar, D., Karuthadurai, T., & Upadhyay, A. (2018). Phenotypic and genetic parameters estimation for birth weight in Zebu and crossbred calves born under organized farm conditions in India. *International Journal of Livestock Research, 8*, 48-58.

Tao, S., & Dahl, G.E. (2013). Heat stress effects during late gestation on dry cows and their calves. *Journal of Dairy Science, 96*(7), 4079-4093.

Thomas, C.K., Sastry, N.S.R., & Ravikiran, G. (2012). Population genetics. In: *Dairy Bovine Production,* Thomas, C.K., Sastry, N.S.R. and Ravikiran, G., 2nd Eds. pp. 353-381.

Upadhyay, D., Gaur, GK, Bharti, P.K., Singh, M., & Dutt, T. (2017). Investigating reasons for lower birth weight in crossbred calves. *Indian Journal of Animal Sciences, 87*(9), 1145-1148.

Wakchaure, R.S., & Meena, R. (2010). Factors affecting birth weight, age, and weight at first calving in Sahiwal cattle. *Indian Journal of Animal Research, 44*(3), 173-177.