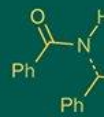


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Productive and reproductive performance of Holdeo (Holstein Friesian × Deoni) cattle maintained under organised farm conditions

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Abstract

Holdeo is the 50 percent Holstein Friesian × Deoni half-bred developed at the Cattle Cross Breeding Project of Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani. Records of 384 Holdeo cows that calved between 2000 and 2025 were analysed by least squares procedures to estimate productive and reproductive performance and to test the effects of period of calving, season of calving and age at first calving group. Overall least squares means were 1472.69 ± 20.34 kg for lactation milk yield, 5.36 ± 0.05 kg for mean daily yield, 46.39 ± 1.02 days for days required to attain peak yield, 275.84 ± 2.72 days for lactation length, 186.16 ± 7.99 days for dry period, 1642.29 ± 7.19 days for age at first calving, 183.77 ± 8.18 days for service period, 280.36 ± 0.63 days for gestation period and 463.37 ± 8.14 days for calving interval. Period of calving affected lactation milk yield, mean daily yield, lactation length, dry period, service period and calving interval, while season of calving affected none of the nine traits. Lactation milk yield rose by 66.70 percent and mean daily yield by 84.8 percent between the first and the last period, and the herd yielded about 1.85 times as much milk per lactation as Deoni cows recorded under field conditions. Reproductive performance did not improve over the same 26 years. Age at first calving of 54 months, a service period of 184 days and a calving interval of 463 days each exceeded the accepted optimum by a wide margin, and the final period combined the highest milk yield with the longest service period, dry period and calving interval of the study. Since gestation length was almost invariant, shortening the service period would add most to lifetime output.

Keywords: Holdeo cattle, crossbred cattle, lactation milk yield, mean daily yield, service period, calving interval

Introduction

Crossbreeding indigenous cattle with exotic dairy breeds has been the principal route to higher milk yield in India since the 1960s. The reasoning is straightforward. Half of the exotic inheritance is expected to raise production, while the indigenous half is expected to retain heat tolerance, tick resistance and the ability to perform on locally available roughage. Whether a particular cross delivers on both counts can only be judged from long-term herd records.

Deoni is a dual-purpose Zebu breed of the Marathwada region of Maharashtra and adjoining parts of Karnataka and Telangana. Its milk yield is modest. Narsimha *et al.* (2019) ^[19] recorded a lactation yield of 796.31 ± 8.14 litres in 228.60 ± 1.55 days in Telangana, and Dongre *et al.* (2017) ^[4], reviewing published work on the breed, reported lactation yields ranging from 238.86 to 868.24 kg. Das *et al.* (2011) ^[3] and Bhutkar *et al.* (2014) ^[2] obtained values of the same order under intensive management.

The Cattle Cross Breeding Project at Parbhani began crossing Holstein Friesian bulls with Deoni cows in 1972, and the resulting half-bred is known locally as Holdeo (Aglave *et al.*, 2010) ^[1]. Several studies have been carried out on this herd. Wondifraw *et al.* (2013) ^[13] examined non-genetic sources of variation in milk production, Mote *et al.* (2014) ^[8] analysed lactation yield and lactation length, Zewdu *et al.* (2015) ^[14] reported reproductive traits, and Thorat *et al.* (2019) ^[12] compared lactation curve models on first-lactation test-day records. Each of these drew on roughly a decade of data.

A herd that has been under selection for more than fifty years is worth re-examining over a longer window, because trends in production and in fertility need not move together and a

short series can conceal that. The present study analysed 26 years of records, from 2000 to 2025, on 384 Holdeo cows, with the object of estimating productive and reproductive performance and of measuring the influence of period of calving, season of calving and age at first calving.

Materials and Methods

Location of the study and herd management

The investigation was carried out at the Cattle Cross Breeding Project, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (19° 16' N, 76° 47' E, 409 m above mean sea level). The region has a semi-arid climate with a mean annual rainfall of about 900 mm, most of it between June and September. Animals were maintained in open loose housing with shaded standing space. The herd was fed seasonal green fodder, sorghum and maize stover, and a compounded concentrate mixture offered according to milk yield, with water available at all times. Cows were milked twice daily by hand and milk yield was recorded at each milking. Breeding was by artificial insemination using frozen semen of Holstein Friesian and Holdeo bulls, and animals were dewormed and vaccinated as per the farm schedule.

Source and structure of data

Data were extracted from pedigree sheets, daily milk registers, breeding registers and calving records maintained at the project. Records of 384 Holdeo cows that calved between 2000 and 2025 were used. Lactations terminated by abortion, death, sale or udder disorder, and records with incomplete calving or insemination dates, were excluded before analysis.

Traits studied

Five productive traits were studied: lactation milk yield (LMY, kg), peak milk yield (PMY, kg), days required to attain peak milk yield (DRPMY, days), lactation length (LL, days) and dry period (DP, days). Four reproductive traits were studied: age at first calving (AFC, days), service period (SP, days), gestation period (GP, days) and calving interval (CI, days). Lactation milk yield was the total milk recorded from calving to drying off. Peak milk yield was the highest yield recorded in the lactation and days required to attain peak yield was the interval from calving to that record. Lactation length was the interval from calving to drying off and dry period the interval from drying off to the next calving. Age at first calving was the interval from birth to first calving, service period the interval from calving to the conception that followed, gestation period the interval from that conception to the next calving, and calving interval the interval between two successive calvings.

Classification of data

Records were classified by period of calving, season of calving and age at first calving group. The 26 years were divided into five periods: P₁ (2000-2004), P₂ (2005-2009), P₃ (2010-2014), P₄ (2015-2019) and P₅ (2020-2025). Calvings were assigned to three seasons on the basis of the calving month: S₁, summer (February to May); S₂, rainy (June to September); and S₃, winter (October to January). Cows were placed in five age at first calving groups: A₁ (up to 1200 days), A₂ (1201-1500 days), A₃ (1501-1800 days), A₄ (1801-2100 days) and A₅ (above 2100 days).

Statistical model and analysis

Data were analysed by least squares procedures (Harvey, 1990) [5] using the MAUSTAT (2000) [7] statistical package. The following fixed effects model was fitted:

$$Y_{ijkl} = \mu + P_i + S_j + A_k + e_{ijkl}$$

where,

Y_{ijkl} = observation on the l th cow calving in the i th period, j th season and belonging to the k th age at first calving group

μ = overall population mean

P_i = fixed effect of the i th period of calving ($i = 1$ to 5)

S_j = fixed effect of the j th season of calving ($j = 1$ to 3)

A_k = fixed effect of the k th age at first calving group ($k = 1$ to 5)

e_{ijkl} = random error, assumed to be normally and independently distributed with zero mean and constant variance

Age at first calving was omitted from the model when it was itself the dependent variable. Differences between subclass means were tested by Kramer's (1957) [6] modification of Duncan's multiple range test. Effects were declared significant at $p < 0.05$ and highly significant at $p < 0.01$.

Results and Discussion

Least squares means for the nine traits are given in Table 1, by period of calving in Table 2 and by season of calving and age at first calving group in Table 3. The analysis of variance is summarised in Table 4 and the comparison with published reports in Table 5.

Consistency of the data set

Two arithmetic identities link the traits studied and offer a check on the records before any interpretation is attempted. Calving interval should equal service period plus gestation period, and it should also equal lactation length plus dry period. The observed calving interval of 463.37 days differed from the sum of service period and gestation period (464.13 days) by 0.76 days, and from the sum of lactation length and dry period (462.00 days) by 1.37 days. Both discrepancies are small relative to the standard errors of the component traits, so the data set is arithmetically coherent and the subsequent comparisons rest on a sound base.

1. Lactation milk yield

The overall least squares mean for lactation milk yield was 1472.69 ± 20.34 kg (Table 1). Period of calving had a highly significant effect ($p < 0.01$). Yield rose from 990.87 ± 44.87 kg in P₁ to 1651.77 ± 48.49 kg in P₅, a gain of 660.90 kg or 66.70 percent, which works out to an average of about 25 kg per year over the study period. Season of calving and age at first calving group had no significant effect, although cows calving in winter (S₃) and those in the A₅ group returned somewhat higher numerical means.

The mean obtained here exceeds the 1266.40 ± 46.69 litres reported by Mote *et al.* (2014) [8] for the same herd. That study drew on earlier records, and the difference is consistent with the upward trend across periods found in the present data. Wondifraw *et al.* (2013) [13] reported 1661.35 ± 15.17 kg for Holstein Friesian × Deoni cows at the same station, a figure close to the P₅ mean of 1651.77 kg recorded here.

Set against the Deoni parent population the contribution of the exotic inheritance is clear. Narsimha *et al.* (2019) ^[19] recorded 796.31 litres per lactation in Deoni cows, so Holdeo cows in this study produced about 1.85 times as much milk, an advantage of roughly 676 kg per lactation. The values reviewed by Dongre *et al.* (2017) ^[4] for Deoni, from 238.86 to 868.24 kg, place the present mean well above the range reported for the indigenous breed.

The significant period effect agrees with Wondifraw *et al.* (2013) ^[13] and Bhutkar *et al.* (2014) ^[2]. It reflects changes in bull selection, concentrate feeding, fodder conservation and herd health management rather than any single intervention. The absence of a season effect differs from Mote *et al.* (2014) ^[8], who found winter calvers superior, and from Wondifraw *et al.* (2013) ^[13], who reported a significant season effect for lactation yield in this herd. Pooling calvings over 26 years inflates the residual variance and reduces the power to detect seasonal contrasts, and improvements in shading and in stored fodder over the same period would tend to narrow the differences between seasons.

2. Peak milk yield and mean daily yield

The trait recorded as peak milk yield averaged 5.36 ± 0.05 kg. Period of calving had a highly significant effect ($F = 94.181$, $p < 0.01$), with a rise from 3.38 ± 0.11 kg in P_1 to 6.38 ± 0.12 kg in P_5 , an improvement of 88.76 percent. Season of calving and age at first calving group were not significant.

Across all thirteen subclass means the recorded value was equal to lactation milk yield divided by lactation length. In P_1 the ratio is 3.43 kg against a recorded 3.38 kg, in P_5 it is 6.33 kg against 6.38 kg, and over the whole data set 5.34 kg against 5.36 kg. The mean absolute departure across the thirteen subclasses was 0.70 percent and the largest was 1.33 percent, with a correlation of 0.998 between the recorded values and the ratio. The trait therefore measures mean daily yield over the lactation rather than the highest daily yield attained, and it is interpreted here on that basis. A true peak exceeds mean daily yield by about 1.3 to 1.5 times; in the Deoni data of Narsimha *et al.* (2019) ^[19] the ratio is $4.68 \div 3.48 = 1.34$, which would place the peak of the present herd near 7 kg.

Read as mean daily yield the trait gives a cleaner measure of productivity than lactation yield alone, because it is not inflated by a long lactation. Holdeo cows averaged 5.34 kg per day of lactation against 3.48 kg for the Deoni cows of Narsimha *et al.* (2019) ^[19], an advantage of 1.53 times. Wondifraw *et al.* (2013) ^[13] reported 5.65 ± 0.04 kg per day of lactation for Holstein Friesian $\times$ Deoni cows at this same station, close to the present value.

The rise from 3.43 kg per day in P_1 to 6.33 kg per day in P_5 , an increase of 84.8 percent, is the most direct evidence of improvement in this herd. It exceeds the 66.70 percent gain in lactation yield because lactation length fell over the same period, so the later cows produced more milk per day of a shorter lactation.

3. Days required to attain peak milk yield

Cows reached peak production 46.39 ± 1.02 days after calving. None of the three effects was significant ($F = 0.875$ for period, 1.220 for season and 1.240 for age at first calving group). Subclass means lay between 44.61 days in the A_4 group and 51.28 days in A_5 , with P_2 (49.99 ± 2.18 days) and

winter calvers (S_3 , 48.59 ± 1.79 days) highest in their respective classifications.

Narsimha *et al.* (2019) ^[19] reported 46.83 ± 0.20 days for Deoni cows in Telangana. The two estimates differ by less than half a day, despite different genetic groups, management systems and regions. Time to peak appears to be governed by the physiology of early lactation and to respond very little to period, season or age at first calving. The trait therefore has limited value as a selection or management criterion, though its stability makes it useful for standardising test-day records.

4. Lactation length

Lactation length averaged 275.84 ± 2.72 days and was highly significantly affected by period of calving ($F = 6.385$, $p < 0.01$). The longest lactations occurred in P_2 (295.88 ± 5.80 days), followed by P_1 (289.30 ± 6.01 days), and the shortest in P_5 (260.94 ± 6.49 days). The decline over the last three periods was steady: 270.48 ± 5.84 days in P_3 , 262.59 ± 5.87 in P_4 and 260.94 ± 6.49 in P_5 . Season of calving and age at first calving group had no significant effect.

The mean is shorter than the 287.19 ± 2.75 days reported by Mote *et al.* (2014) ^[8] and the 296.80 ± 2.29 days reported by Wondifraw *et al.* (2013) ^[13] for the same crossbred at this station. It is longer than the 228.60 ± 1.55 days recorded for Deoni by Narsimha *et al.* (2019) ^[19] and falls in the upper part of the 149.43 to 293.3 day range reviewed by Dongre *et al.* (2017) ^[4].

The fall of 34.94 days between P_2 and P_5 coincided with the highest lactation yield of the study. Mean yield per day of lactation in P_5 was 6.33 kg against 5.34 kg for the data set as a whole, so the later cows were more productive on a daily basis while being dried off earlier. Whether the shorter lactations reflect a deliberate change in drying-off practice or the culling of cows that failed to persist cannot be settled from these records, and test-day data would be needed to separate the two.

5. Dry period

The dry period averaged 186.16 ± 7.99 days. Period of calving had a significant effect ($F = 3.286$, $p < 0.05$): the dry period fell from 190.40 ± 17.62 days in P_1 to 145.35 ± 17.20 days in P_4 , then rose sharply to 233.70 ± 19.04 days in P_5 . Season of calving and age at first calving group had no significant effect, although winter calvers (S_3 , 205.60 ± 13.91 days) and the A_1 group (207.21 ± 20.74 days) returned the highest numerical means.

This is appreciably longer than the 126.90 ± 1.76 days reported by Zewdu *et al.* (2015) ^[14] for Holstein Friesian $\times$ Deoni cows at the same station, and longer than the 160 days that follow from the 5.27 month dry period recorded for Deoni by Narsimha *et al.* (2019) ^[19]. Dongre *et al.* (2017) ^[4] cited values between 103.66 and 282.77 days for Deoni, so the present mean sits in the upper half of that range.

A dry period of 60 to 90 days is generally regarded as sufficient for udder involution and for the recovery of body condition. At 186 days the herd carries each cow for roughly six months without return. Since dry period is the difference between calving interval and lactation length, and calving interval here was driven almost entirely by service period, the long dry period follows from delayed conception rather than from any decision to dry cows off early.

6. Age at first calving

Age at first calving averaged 1642.29 ± 7.19 days, or about 54 months. Period and season of calving had no significant effect, although age at first calving fell by 61.58 days, about two months, between P_1 (1661.28 ± 15.86 days) and P_5 (1599.70 ± 17.13 days). Age at first calving groups differed highly significantly, with means rising from 1159.79 ± 18.66 days in A_1 to 2253.63 ± 17.89 days in A_5 . This difference is a property of the classification itself, since cows were assigned to groups on the basis of the trait being tested, and it carries no biological meaning. The grouping is informative only for the traits recorded after first calving. The value obtained here is 443.75 days higher than the 1198.54 ± 8.18 days reported by Zewdu *et al.* (2015) ^[14] for the same crossbred at this station, and it lies above the 1070.80 to 1533 day range that Dongre *et al.* (2017) ^[4] reported for Deoni. The comparison that matters most is with Narsimha *et al.* (2019) ^[19], who recorded 54.28 months for Deoni cows kept by farmers in Telangana. A half-bred maintained on an organised research farm calved no earlier than an indigenous cow in a village herd. This points to heifer rearing rather than to genotype as the factor holding the herd back.

An age at first calving of 30 months is commonly recommended for half-bred crossbreds and is attainable when heifers reach about 250 to 275 kg by 18 months. The two-year delay observed here removes roughly one and a half lactations from the productive life of every animal and adds two years of feeding, housing and health cost before the first return. Growth monitoring with periodic weighing, breeding on body weight rather than on age alone, better heifer nutrition between six and eighteen months, and systematic heat detection in maiden heifers are the measures most likely to reduce it.

7. Service period

The service period averaged 183.77 ± 8.18 days and was highly significantly affected by period of calving ($F = 3.849$, $p < 0.01$). It fell from 201.47 ± 18.05 days in P_1 through 192.76 ± 17.41 in P_2 and 173.36 ± 17.54 in P_3 to 130.01 ± 17.62 days in P_4 , then rose to 221.25 ± 19.51 days in P_5 . Season of calving and age at first calving group had no significant effect.

Zewdu *et al.* (2015) ^[14] reported 149.15 ± 3.87 days open for Holstein Friesian $\times$ Deoni cows at this station, and Narsimha *et al.* (2019) ^[19] recorded 5.12 months, about 156 days, for Deoni. Dongre *et al.* (2017) ^[4] cited a range of 152.14 to 286.57 days. Against a desirable service period of 60 to 90 days, the present mean is two to three times longer. The pattern across periods deserves attention. P_5 combined the highest lactation yield of the study (1651.77 kg) and the highest daily yield (6.33 kg) with the longest service period (221.25 days), the longest dry period (233.70 days) and the longest calving interval (499.39 days). P_4 combined lower production with the shortest service period (130.01 days), the shortest dry period (145.35 days) and the shortest calving interval (407.96 days). Four reproductive measures moved together and against yield, which makes the pattern harder to attribute to chance in any one trait. An antagonism between milk yield and the interval to conception is well documented in dairy cattle and is usually attributed to a deeper and more prolonged negative energy balance in early lactation in higher-yielding cows. The present data cannot separate that from a concurrent change in the breeding routine, but the pattern is consistent across the reproductive traits.

Practical measures follow directly. Heat detection twice daily with written records, examination of the reproductive tract between days 45 and 60 after calving, treatment of postpartum anoestrus and repeat breeding, and adequate energy and mineral supplementation during the first ten weeks of lactation would each contribute to shortening the interval.

8. Gestation period

Gestation period averaged 280.36 ± 0.63 days and was unaffected by period ($F = 2.343$), season ($F = 1.321$) or age at first calving group ($F = 1.196$). Subclass means ranged only from 278.44 ± 1.52 days in P_5 to 283.80 ± 1.35 days in P_2 , a span of 5.36 days across all thirteen subclasses. Its standard error was 0.22 percent of the mean, the smallest relative error among the nine traits.

Narsimha *et al.* (2019) ^[19] recorded a gestation period of 9.25 months for Deoni, about 281 days, which is within a day of the value obtained here. Gestation length in Holstein Friesian is usually reported between 278 and 282 days, so the crossbred falls inside the range expected of both parent populations and the exotic inheritance has not altered it. Gestation length is under the genetic control of the foetus and responds very little to the dam's environment, which is why no effect was significant. Its practical importance lies in setting a floor of about 280 days below which the calving interval cannot fall.

9. Calving interval

Calving interval averaged 463.37 ± 8.14 days, or about 15.2 months, and was highly significantly affected by period of calving ($F = 3.954$, $p < 0.01$). It fell from 481.52 ± 17.96 days in P_1 to 407.96 ± 17.53 days in P_4 , the only period in which it approached an acceptable value, and then rose to 499.39 ± 19.40 days in P_5 . Season of calving and age at first calving group had no significant effect.

Zewdu *et al.* (2015) ^[14] reported 422.95 ± 2.53 days at the same station. Narsimha *et al.* (2019) ^[19] recorded 15.41 months, about 468 days, for Deoni under field conditions, which is within a week of the value obtained here for a crossbred herd on an organised farm. Dongre *et al.* (2017) ^[4] cited intercalving periods between 447.0 and 566.1 days for Deoni.

A calving interval of 12 to 13 months is generally accepted as the economic optimum. Because calving interval is the sum of service period and gestation period, and gestation period varied hardly at all, the entire scope for improvement lies in the service period. Gestation contributed 60.5 percent of the calving interval but almost none of its variation.

The arithmetic of the loss is worth stating plainly. At a calving interval of 463.37 days a herd completes 78.8 calvings per 100 cow-years. At 400 days it would complete 91.3. The difference of 12.5 lactations is worth about 18,400 kg of milk per 100 cow-years at the lactation yield observed in this study, before any account is taken of the extra calves born.

Production and reproduction over the study period

Taken together the results show a herd that improved on one axis and not on the other. Between P_1 and P_5 lactation yield rose by 66.70 percent and mean daily yield by 84.8 percent. Over the same 26 years age at first calving improved by only two months and not significantly, while service period, dry period and calving interval were all at their longest in the final period.

The contrast between P₄ and P₅ is the sharpest result in the data. P₄ returned a calving interval of 407.96 days, a service period of 130.01 days and a dry period of 145.35 days, the best reproductive performance of the study, on a lactation yield of 1577.06 kg. P₅ raised lactation yield by 74.71 kg, or 4.7 percent, and gave back 91.43 days of calving interval, 91.24 days of service period and 88.35 days of dry period. At 407.96 days a herd completes 89.5 calvings per 100 cow-years against 73.1 at 499.39 days, so the small gain in yield per lactation was bought at the cost of about a fifth of the lactations.

Selection and management at this farm have therefore acted on production alone. This outcome is common in crossbred herds where replacement bulls are chosen on the milk records of their dams without any fertility criterion, and where reproductive performance is treated as a routine matter rather than as a recorded trait. The productive potential of Holdeo cattle demonstrated here is real. What limits its return is the number of lactations each cow completes, and that is a reproductive question, not a genetic one.

Table 1: Overall least squares means with standard errors and significance of period of calving, season of calving and age at first calving group for productive and reproductive traits of Holdeo cows (n = 384)

Trait	Unit	Overall LS mean ± SE	Period	Season	AFC group
Lactation milk yield (LMY)	kg	1472.69 ± 20.34	**	NS	NS
Mean daily yield (PMY)†	kg	5.36 ± 0.05	**	NS	NS
Days to attain peak yield (DRPMY)	days	46.39 ± 1.02	NS	NS	NS
Lactation length (LL)	days	275.84 ± 2.72	**	NS	NS
Dry period (DP)	days	186.16 ± 7.99	*	NS	NS
Age at first calving (AFC)	days	1642.29 ± 7.19	NS	NS	**‡
Service period (SP)	days	183.77 ± 8.18	**	NS	NS
Gestation period (GP)	days	280.36 ± 0.63	NS	NS	NS
Calving interval (CI)	days	463.37 ± 8.14	**	NS	NS

** $p < 0.01$; * $p < 0.05$; NS = not significant. † The trait recorded as peak milk yield equals lactation milk yield divided by lactation length across all subclasses and is interpreted as mean daily yield; see Results. ‡ The effect of AFC group on AFC itself follows from the classification and has no biological interpretation.

Table 2: Least squares means ± SE for productive and reproductive traits of Holdeo cows by period of calving

Period	n	LMY (kg)	MDY (kg)	LL (d)	DP (d)	AFC (d)	SP (d)	CI (d)
P ₁ (2000-2004)	75	990.87 ± 44.87	3.38 ± 0.11	289.30 ± 6.01	190.40 ± 17.62	1661.28 ± 15.86	201.47 ± 18.05	481.52 ± 17.96
P ₂ (2005-2009)	82	1546.16 ± 43.28	5.22 ± 0.11	295.88 ± 5.80	177.41 ± 17.00	1645.60 ± 15.29	192.76 ± 17.41	473.43 ± 17.32
P ₃ (2010-2014)	78	1597.57 ± 43.61	5.87 ± 0.11	270.48 ± 5.84	183.96 ± 17.13	1660.31 ± 15.41	173.36 ± 17.54	454.53 ± 17.45
P ₄ (2015-2019)	83	1577.06 ± 43.80	5.97 ± 0.11	262.59 ± 5.87	145.35 ± 17.20	1644.55 ± 15.48	130.01 ± 17.62	407.96 ± 17.53
P ₅ (2020-2025)	66	1651.77 ± 48.49	6.38 ± 0.12	260.94 ± 6.49	233.70 ± 19.04	1599.70 ± 17.13	221.25 ± 19.51	499.39 ± 19.40
Overall	384	1472.69 ± 20.34	5.36 ± 0.05	275.84 ± 2.72	186.16 ± 7.99	1642.29 ± 7.19	183.77 ± 8.18	463.37 ± 8.14
Significance		**	**	**	*	NS	**	**

** $p < 0.01$; * $p < 0.05$; NS = not significant. MDY = mean daily yield, the trait recorded as peak milk yield.

Table 3: Least squares means ± SE for productive and reproductive traits of Holdeo cows by season of calving and age at first calving group

Class	n	LMY (kg)	MDY (kg)	LL (d)	DP (d)	AFC (d)	SP (d)	CI (d)
S ₁	104	1435.84 ± 38.17	5.36 ± 0.09	270.25 ± 5.11	176.34 ± 14.99	1626.23 ± 13.49	166.59 ± 15.35	448.07 ± 15.27
S ₂	160	1445.25 ± 30.56	5.24 ± 0.07	278.87 ± 4.09	176.55 ± 12.00	1647.00 ± 10.80	180.15 ± 12.29	457.76 ± 12.23
S ₃	120	1536.97 ± 35.43	5.50 ± 0.09	278.40 ± 4.75	205.60 ± 13.91	1653.63 ± 12.52	204.57 ± 14.25	484.26 ± 14.18
Significance		NS	NS	NS	NS	NS	NS	NS
A ₁ (<1200 d)	54	1465.43 ± 52.81	5.29 ± 0.13	280.09 ± 7.07	207.21 ± 20.74	1159.79 ± 18.66	211.89 ± 21.24	490.92 ± 21.13
A ₂ (1201-1500)	77	1386.83 ± 43.28	5.18 ± 0.11	268.50 ± 5.80	179.34 ± 17.00	1406.30 ± 15.29	166.71 ± 17.41	448.98 ± 17.32
A ₃ (1501-1800)	120	1496.67 ± 34.76	5.34 ± 0.09	284.01 ± 4.66	194.57 ± 13.65	1588.78 ± 12.28	198.51 ± 13.98	478.56 ± 13.19
A ₄ (1801-2100)	72	1438.69 ± 45.76	5.40 ± 0.11	265.48 ± 6.13	176.38 ± 17.97	1802.94 ± 16.17	161.70 ± 18.41	443.76 ± 18.31
A ₅ (>2100 d)	61	1575.81 ± 50.62	5.62 ± 0.13	281.12 ± 6.78	173.32 ± 19.88	2253.63 ± 17.89	180.05 ± 20.36	454.60 ± 20.26
Significance		NS	NS	NS	NS	**‡	NS	NS

** $p < 0.01$; NS = not significant. ‡ Follows from the classification; see the footnote to Table 1.

Table 4: Analysis of variance: calculated F values for the effects of period of calving, season of calving and age at first calving group

Trait	F (period)	F (season)	F (AFC group)	df (effect)	df (error)
LMY	3.52**	2.52 NS	2.28 NS	4/2/4	373
MDY (PMY)	94.18**	2.35 NS	1.69 NS	4/2/4	373
DRPMY	0.88 NS	1.22 NS	1.24 NS	4/2/4	373
LL	6.39**	1.00 NS	2.11 NS	4/2/4	373
DP	3.29*	1.51 NS	0.54 NS	4/2/4	373
AFC	2.27 NS	1.21 NS	507.62**	4/2/4	373
SP	3.85**	1.73 NS	1.28 NS	4/2/4	373
GP	2.34 NS	1.32 NS	1.20 NS	4/2/4	373
CI	3.95**	1.69 NS	1.17 NS	4/2/4	373

** $p < 0.01$; * $p < 0.05$; NS = not significant. Tabulated F at 4 and 373 degrees of freedom is 2.396 at $p < 0.05$ and 3.370 at $p < 0.01$; at 2 and 373 degrees of freedom it is 3.020 and 4.662.

Table 5: Performance of Holdeo cows in the present study compared with published reports on the same crossbred, on Deoni cattle, and with generally recommended values

Trait	Present study (Holdeo, 2000-2025)	Holdeo/HF × Deoni, same station	Deoni	Suggested optimum
LMY (kg)	1472.69	1266.40 ^a ; 1661.35 ^b	796.31 ^c ; 238.86-868.24 ^d	—
Mean daily yield (kg)	5.34	5.65 ^b	3.48 ^c	—
DRPMY (days)	46.39	—	46.83 ^c	—
LL (days)	275.84	287.19 ^a ; 296.80 ^b	228.60 ^c ; 149.43-293.30 ^d	300-305
DP (days)	186.16	126.90 ^c	160 ^c ; 103.66-282.77 ^d	60-90
AFC (days)	1642.29	1198.54 ^c	1650 ^c ; 1070.80-1533 ^d	~900 (30 months)
SP (days)	183.77	149.15 ^c	156 ^c ; 152.14-286.57 ^d	60-90
GP (days)	280.36	—	281 ^c	—
CI (days)	463.37	422.95 ^c	468 ^c ; 447.0-566.1 ^d	365-400

a = Mote *et al.* (2014) ^[8]; b = Wondifraw *et al.* (2013) ^[13]; c = Narsimha *et al.* (2019) ^[19]; d = Dongre *et al.* (2017) ^[4], range across reviewed studies; e = Zewdu *et al.* (2015) ^[14]. Values reported in months have been converted at 30.4 days per month.

Conclusion

Holdeo cows maintained under organised farm conditions at Parbhani averaged 1472.69 ± 20.34 kg of milk in a lactation of 275.84 ± 2.72 days, or 5.34 kg per day of lactation, and reached maximum production 46.39 ± 1.02 days after calving. Lactation yield improved by 66.70 percent and mean daily yield by 84.8 percent between 2000-2004 and 2020-2025, and the herd out-yielded the Deoni parent population by a factor of 1.85 per lactation and 1.53 per day of lactation. Period of calving affected lactation yield, mean daily yield, lactation length, dry period, service period and calving interval, while season of calving affected none of the nine traits.

Reproductive performance did not improve over the same period and remained well short of accepted standards. Age at first calving of 1642.29 ± 7.19 days, a service period of 183.77 ± 8.18 days, a dry period of 186.16 ± 7.99 days and a calving interval of 463.37 ± 8.14 days each exceeded the optimum by a wide margin, and the crossbred herd calved no earlier and no more frequently than Deoni cows recorded under village conditions.

Because gestation length was almost invariant at 280.36 ± 0.63 days, varying by only 5.36 days across all thirteen subclasses, the whole of the improvement available in the calving interval lies in the service period. Priority should go to heifer growth monitoring and weight-based breeding to bring age at first calving towards 30 months, to twice-daily heat detection with written records, to postpartum reproductive examination between days 45 and 60, and to energy and mineral supplementation in early lactation. Continued selection for milk yield should be accompanied by the recording of fertility traits, so that the gains already achieved in production translate into more lactations per cow.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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