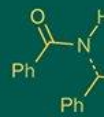


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Breeding efficiency and its correlations with production traits in Holdeo (Holstein Friesian × Deoni) cattle

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Abstract

Breeding efficiency was estimated by two methods, and its correlations with five production traits examined, in 384 Holdeo (50 percent Holstein Friesian × Deoni) cows that calved between 2000 and 2025 at the Cattle Cross Breeding Project, Parbhani. Breeding efficiency averaged 72.55 ± 0.44 percent by the Tomar (1965) method and 83.02 ± 0.82 percent by the Wilcox (1957) method. The two methods behaved differently. By the Tomar method, breeding efficiency was affected by period of calving ($p < 0.01$) and very strongly by age at first calving group ($F = 78.64$, $p < 0.01$), falling from 85.73 ± 1.15 percent in cows calving first before 1200 days to 58.89 ± 1.10 percent in those calving after 2100 days, a loss of 0.75 percentage points for every month of delay. By the Wilcox method no effect was significant. The difference follows from the formulae: age at first calving enters the Tomar denominator and does not enter the Wilcox expression, which reduces to 365 divided by the calving interval. Measured by the Wilcox method the herd matched published crossbred values (83.02 against 82.31 percent), while by the Tomar method it fell 25.59 percentage points short, the whole of the shortfall arising from an age at first calving of 1642 days against an optimum of 1020. Heritability and repeatability estimates for all eight traits were negative and differed from each other by exactly 0.0100 in every trait, which indicates a computational artefact rather than eight independent estimates. The correlations reported alongside them should therefore be treated as preliminary.

Keywords: Holdeo cattle, breeding efficiency, Tomar method, Wilcox method, age at first calving, crossbred cattle

Introduction

A dairy cow returns milk only in proportion to how often she calves. Breeding efficiency condenses a cow's whole reproductive history into one figure by setting what she achieved against what an optimum cow would have achieved, and it is used in Indian herd evaluation because it summarises age at first calving and every subsequent calving interval in a single number that can be compared across animals and across herds.

Two formulae are in common use and they do not measure quite the same thing. The method of Wilcox (1957) ^[21] works only from the calving intervals a cow completed. The method of Tomar (1965) ^[22] adds age at first calving to the denominator, so it penalises a heifer that entered the herd late even if she calved regularly afterwards. Raina *et al.* (2016) ^[16] and Singh *et al.* (2016) ^[14] applied both to the same crossbred cows and obtained 82.31 ± 0.97 percent by Wilcox and 98.14 ± 1.09 percent by Tomar, a gap of nearly sixteen points, which shows how much the choice of formula matters.

Holdeo is the 50 percent Holstein Friesian × Deoni half-bred developed at the Cattle Cross Breeding Project, Parbhani, where crossing began in 1972 (Aglave *et al.*, 2010) ^[1]. Milk production in this herd and its non-genetic sources of variation have been reported by Wondifraw *et al.* (2013) ^[18] and Mote *et al.* (2014) ^[8], reproductive traits by Zewdu *et al.* (2015) ^[20] and lactation curve models by Thorat *et al.* (2019) ^[16]. Breeding efficiency has not been reported, and neither has its relationship with the production traits.

That relationship decides whether a breeding programme built on milk records will carry reproductive performance along with it or leave it behind. Published estimates suggest the latter.

Worku *et al.* (2021) ^[19] obtained heritabilities of 0.19 ± 0.03 for lactation milk yield and 0.06 ± 0.01 for calving interval in Karan Fries cattle, and Vinothraj *et al.* (2016) ^[16] obtained 0.222 ± 0.101 for calving interval and 0.177 ± 0.115 for dry period in Jersey $\times$ Red Sindhi crossbreds, where the standard error is as large as the estimate. The present study estimated breeding efficiency in Holdeo cattle by both methods, tested it against period of calving, season of calving and age at first calving group, and examined its correlations with the production traits.

Materials and Methods

Source of data

Records of 384 Holdeo cows that calved between 2000 and 2025 at the Cattle Cross Breeding Project, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, were used. Data were drawn from pedigree sheets, daily milk registers and breeding registers. Lactations terminated by abortion, death, sale or udder disorder were excluded. Records were classified into five periods of calving (P_1 , 2000-2004 to P_5 , 2020-2025), three seasons of calving (S_1 , S_2 and S_3) and five age at first calving groups (A_1 , up to 1200 days, to A_5 , above 2100 days).

Traits studied

Five production traits were studied: lactation milk yield (LMY, kg), the trait recorded as peak milk yield (PMY, kg), days required to attain peak milk yield (DRPMY, days), lactation length (LL, days) and dry period (DP, days). Breeding efficiency (BE, percent) was the sixth trait.

Estimation of breeding efficiency

Breeding efficiency was computed by two methods. The method of Tomar (1965) ^[22], as given by Singh *et al.* (2016) ^[14], is:

$$BE (\%) = [(365N + 1020)/(AFC + \Sigma CI)] \times 100$$

and the method of Wilcox (1957) ^[21] is:

$$BE (\%) = [365 (n - 1)/D] \times 100$$

where,

N = total number of calving intervals

n = total number of parturitions

AFC = age at first calving, days

ΣCI = sum of all calving intervals, days

D = interval from first to last parturition, days

365 = optimum calving interval, days

1020 = optimum age at first calving in cattle, days

The two expressions differ in one respect that governs everything reported below. Age at first calving appears in the Tomar denominator and does not appear in the Wilcox expression at all. Because D is itself the sum of the calving intervals, the Wilcox formula reduces to 365 divided by the mean calving interval, and is therefore blind to how late the heifer entered the herd.

Statistical analysis

Least squares means for breeding efficiency were obtained by the procedure of Harvey (1990) ^[5] using the MAUSTAT (2000) ^[7] statistical package, fitting the model:

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

where,

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

Subclass means were compared by Duncan's multiple range test as modified by Kramer (1957) ^[6]. Heritability was estimated from the paternal half-sib analysis as $h^2 = 4\sigma^2_s/(\sigma^2_s + \sigma^2_w)$, where σ^2_s is the sire component of variance, and repeatability as the intraclass correlation among repeated records of the same cow (Becker, 1984; Falconer and Mackay, 1996) ^[4]. Correlations among the six traits were tested against tabulated values of r and were declared significant at $p < 0.05$ and highly significant at $p < 0.01$.

Results and Discussion

Least squares means for breeding efficiency by the Tomar and Wilcox methods are given in Tables 1 and 2, the analysis of variance for both in Table 3, heritability and repeatability estimates in Table 4, the correlation matrix in Table 5 and the comparison with published values in Table 6.

Breeding efficiency by the Tomar method

Breeding efficiency by the Tomar method averaged 72.55 ± 0.44 percent (Table 1). Period of calving had a highly significant effect ($F = 3.530$, $p < 0.01$). Efficiency rose from 71.38 ± 0.98 percent in P_1 through 72.46 ± 0.94 in P_2 and 72.81 ± 0.95 in P_3 to 75.40 ± 0.95 percent in P_4 , the highest of the study, and then fell to 70.69 ± 1.06 percent in P_5 , the lowest. Season of calving had no significant effect ($F = 1.571$).

The rise to P_4 and the fall in P_5 follow the calving intervals recorded in this herd, which were shortest in P_4 and longest in P_5 . Efficiency by this measure is not drifting upward with time; it reached its best value in the fourth period and lost that ground in the fifth.

Age at first calving group was by a wide margin the largest source of variation in the whole analysis ($F = 78.64$, $p < 0.01$), more than twenty times the F value for period. Efficiency fell steadily from 85.73 ± 1.15 percent in A_1 , where cows calved first at 1159.79 days, to 78.27 ± 0.94 percent in A_2 , 71.42 ± 0.76 in A_3 , 68.44 ± 1.00 in A_4 and 58.89 ± 1.10 percent in A_5 , where cows calved first at 2253.63 days. The spread of 26.84 percentage points across 1094 days of age at first calving works out at 0.75 percentage points of breeding efficiency lost for every month by which first calving is delayed.

That figure is the practical result of the study. It converts a reproductive delay into a single number a farm manager can act on, and it holds whatever else is happening in the herd, because age at first calving enters the Tomar denominator directly.

Breeding efficiency by the Wilcox method

By the Wilcox method breeding efficiency averaged 83.02 ± 0.82 percent (Table 2). None of the three effects was significant. Period of calving gave $F = 2.204$ against a tabulated value of 2.396 at $p < 0.05$, with means from 80.68

± 1.96 percent in P_5 to 86.58 ± 1.77 percent in P_4 . Season gave $F = 1.651$ and age at first calving group $F = 1.446$, with means between 80.54 ± 1.41 percent in A_3 and 84.76 ± 1.75 percent in A_2 .

The contrast with the Tomar method is complete and it is not a puzzle. Age at first calving does not enter the Wilcoxon expression, so a cow that calved first at 74 months and one that calved first at 38 months score the same provided their subsequent calving intervals are the same. The F value for age at first calving group fell from 78.64 by the Tomar method to 1.446 by the Wilcoxon method, which is what the two formulae predict.

Which method to use, and what the difference reveals

The two estimates differ by 10.47 percentage points in the same herd on the same records. Set against the crossbred cows of Raina *et al.* (2016) ^[16] and Singh *et al.* (2016) ^[14] the pattern is instructive. By the Wilcoxon method Holdeo scored 83.02 percent against their 82.31 percent, a difference of less than a point. By the Tomar method Holdeo scored 72.55 percent against their 98.14 percent, a shortfall of 25.59 points.

Once the formulae are set side by side the reason is plain. On the calving intervals they actually completed, Holdeo cows performed as well as published crossbred herds. What separates them is the age at which they entered the herd: 1642 days against a Tomar optimum of 1020. The entire 25.59-point shortfall is the cost of that delay, and none of it is a shortfall in the calving intervals themselves.

This is a reason to report both figures rather than choose between them. The Wilcoxon estimate says how well the cows cycled once they started; the Tomar estimate says how much of a cow's potential lifetime was spent waiting for the first calf. For a herd whose first calving is two years later than it should be, the second question is the more important one, and a study that reported only the Wilcoxon figure would have concluded that reproductive performance was satisfactory.

Heritability and repeatability

Heritability and repeatability estimates for the eight production and reproductive traits are given in Table 3. Every estimate was negative. Heritability ranged from -0.0537 ± 0.0202 for lactation length to -0.0583 ± 0.0331 for gestation period, and repeatability from -0.0437 ± 0.0175 to -0.0483 ± 0.0225 for the same two traits.

Negative estimates arise when the sire component of variance computed from the analysis of variance falls below zero, which happens when the true value is small relative to the sampling error of a data set with few sires or few daughters per sire. The parameter cannot itself be negative. Steinsaltz *et al.* (2020) ^[15] have shown that truncating such estimates at zero introduces its own bias and that they are better reported than suppressed, which is why they are given here in full.

Two features of Table 3 go beyond the usual explanation. First, seven of the eight heritability estimates lie within 0.0003 of one another, and the eighth within 0.0046. Eight biologically distinct traits, measured in different units and governed by different physiology, do not return the same variance ratio to three decimal places. Second, the difference between the heritability and the repeatability estimate is exactly -0.0100 for all eight traits without exception. Heritability and repeatability are different functions of different variance components and there is no

mechanism by which their difference would be constant across eight traits.

Taken together these two features point to a computational artefact rather than to eight independent findings of zero heritability. The most likely explanation is that the grouping variable used in the analysis of variance carried no real sire structure, in which case the between-group and within-group mean squares are equal apart from rounding and the resulting intraclass correlation is fixed by the design rather than by the data. Whatever the cause, the estimates cannot be read as evidence about the genetic architecture of this population, and neither can any covariance component derived from the same analysis.

Published estimates show what the traits look like when the design supports them. Worku *et al.* (2021) ^[19] obtained 0.19 ± 0.03 for lactation milk yield, 0.06 ± 0.02 for lactation length and 0.06 ± 0.01 for calving interval in Karan Fries cattle. Vinothraj *et al.* (2016) ^[16], working with 732 lactation records accumulated over 30 years, obtained 0.222 ± 0.101 for calving interval and 0.177 ± 0.115 for dry period. Deshpande and Bonde (1981) ^[3] obtained 0.405 ± 0.023 for peak yield on 1346 crossbred cows. Reproductive traits are weakly heritable everywhere, and resolving them takes more sires and more daughters per sire than a single research herd usually holds.

Correlations among the traits

Correlations among the production traits

The correlation matrix is given in Table 5. Lactation milk yield showed large negative correlations with the trait recorded as peak milk yield ($r = -0.715$, $p < 0.01$) and with lactation length ($r = -0.668$, $p < 0.01$), a positive correlation with dry period ($r = 0.285$, $p < 0.01$) and no significant association with days to peak ($r = 0.148$). Peak milk yield correlated positively with lactation length ($r = 0.225$, $p < 0.05$) and dry period ($r = 0.224$, $p < 0.05$). Days to peak correlated positively with lactation length ($r = 0.239$, $p < 0.05$) and dry period ($r = 0.247$, $p < 0.05$). Lactation length and dry period correlated positively ($r = 0.285$, $p < 0.01$).

The negative correlation between lactation milk yield and lactation length is explicable in this herd, and the explanation is a warning rather than a finding. Over the five periods lactation yield rose from 990.87 to 1651.77 kg while lactation length fell from 289.30 to 260.94 days. A correlation computed on records pooled across 26 years without removing that trend will return a negative coefficient between the two traits even where the within-period association is positive. Worku *et al.* (2021) ^[19] obtained genetic correlations above 0.80 among 305-day yield, lactation yield and lactation length in Karan Fries cattle, and phenotypic correlations that were also positive and high. The present coefficient measures the herd's history, not the relationship between the traits.

The negative correlation between lactation milk yield and the trait recorded as peak milk yield is not explicable in the same way. Across the thirteen subclass means of this study the recorded peak yield equals lactation milk yield divided by lactation length to within 1.33 percent, so the two traits rose together across periods, from 990.87 kg and 3.38 kg in P_1 to 1651.77 kg and 6.38 kg in P_5 . Between the period means they correlate at $+0.97$. A coefficient of -0.715 cannot be reconciled with that, nor with the positive coefficient of $+0.225$ reported between peak yield and lactation length in the same matrix. Deshpande and Bonde

(1981) [3] found peak yield positively and highly significantly correlated with total lactation yield on both the genetic and the phenotypic scale in 1346 crossbred cows. This estimate should be re-derived before it is used.

Correlations of breeding efficiency with the production traits

Breeding efficiency correlated positively with dry period ($r = 0.609$, $p < 0.01$) and lactation length ($r = 0.255$, $p < 0.01$), and showed no significant association with lactation milk yield ($r = 0.169$), peak milk yield ($r = -0.135$) or days to peak ($r = -0.048$).

The coefficient for dry period is the largest in the matrix and it runs against the formula that defines the trait. Dry period is a component of the calving interval, and the sum of the calving intervals is the Tomar denominator, so a cow with longer dry periods must score lower on breeding efficiency. The least squares means of this study bear that out: across the five periods, breeding efficiency and dry period correlate at -0.92 , with P_4 combining the highest efficiency (75.40 percent) with the shortest dry period (145.35 days) and P_5 the lowest efficiency (70.69 percent) with the longest dry period (233.70 days).

Across the five age at first calving groups the same two traits correlate at $+0.68$. The reason is that breeding efficiency by the Tomar method is dominated by age at first calving, with which it correlates at -0.98 across those groups, and age at first calving happens also to track dry period, at -0.72 . The A_1 cows calved first at 1159.79 days and scored 85.73 percent while also carrying the longest dry period of 207.21 days; the A_5 cows calved first at 2253.63 days, scored 58.89 percent and carried the shortest dry period of 173.32 days. Pooling across groups therefore produces a positive coefficient from two traits that are negatively related within them.

The reported $+0.609$ is consistent with the second of these patterns and not with the first. It reflects confounding by age at first calving rather than any relationship between udder rest and reproductive efficiency, and it should not be read as a reason to lengthen the dry period. Age at first calving should be fitted as a covariate before the correlation is estimated.

The absence of a significant association between breeding efficiency and lactation milk yield is the practically important result and it is not affected by any of the difficulties above. Selection on milk records alone would not be expected to move breeding efficiency in this population. Reproductive performance will not arrive as a by-product of selection for yield; it has to be recorded, selected for and managed on its own account.

Implications for the herd

Three conclusions follow, in descending order of confidence.

The first is arithmetic and does not depend on any genetic parameter. Every month by which first calving is delayed costs 0.75 percentage points of breeding efficiency by the Tomar measure, and the herd's age at first calving of 1642 days is roughly two years later than the 1020 days the formula treats as optimum. On the calving intervals the cows actually completed they performed as well as published crossbred herds. The whole of the deficit sits in the rearing period before first calving, which is also the part

of the production cycle a farm controls most directly, through heifer nutrition, growth monitoring, breeding on body weight rather than age, and heat detection in maiden heifers.

The second concerns the choice of measure. Reporting breeding efficiency by the Wilcox method alone would have shown this herd performing normally. It is the Tomar method that locates the problem, because it is the only one of the two that counts the cost of a late start. Herd evaluations in populations with delayed first calving should report both.

The third is a limitation. The heritability and repeatability estimates obtained here are not usable, and the correlations computed alongside them inherit that. Genetic parameters for Holdeo cattle should be re-estimated on a pedigree-connected data set with an adequate number of sires and daughters per sire, with the fixed effects of period, season and age at first calving removed before the covariances are computed. Until that is done the correlations in Table 4 mark out where to look rather than what to conclude.

Table 1: Least squares means $\pm$ SE for breeding efficiency (percent) in Holdeo cows by the Tomar (1965) [22] method

Source	Code	n	BE $\pm$ SE (%)
Overall mean	μ	384	72.55 $\pm$ 0.44
Period	P_1	75	71.38 $\pm$ 0.98
	P_2	82	72.46 $\pm$ 0.94
	P_3	78	72.81 $\pm$ 0.95
	P_4	83	75.40 $\pm$ 0.95
	P_5	66	70.69 $\pm$ 1.06
Season	S_1	104	73.29 $\pm$ 0.83
	S_2	160	72.91 $\pm$ 0.66
	S_3	120	71.44 $\pm$ 0.77
AFC group	A_1 (≤ 1200 d)	54	85.73 $\pm$ 1.15
	A_2 (1201-1500)	77	78.27 $\pm$ 0.94
	A_3 (1501-1800)	120	71.42 $\pm$ 0.76
	A_4 (1801-2100)	72	68.44 $\pm$ 1.00
	A_5 (> 2100 d)	61	58.89 $\pm$ 1.10

Period of calving $p < 0.01$; season of calving not significant; age at first calving group $p < 0.01$. See Table 3.

Table 2: Least squares means $\pm$ SE for breeding efficiency (percent) in Holdeo cows by the Wilcox (1957) [21] method

Source	Code	n	BE $\pm$ SE (%)
Overall mean	μ	384	83.02 $\pm$ 0.82
Period	P_1	75	81.83 $\pm$ 1.82
	P_2	82	80.98 $\pm$ 1.75
	P_3	78	85.01 $\pm$ 1.77
	P_4	83	86.58 $\pm$ 1.77
	P_5	66	80.68 $\pm$ 1.96
Season	S_1	104	84.87 $\pm$ 1.54
	S_2	160	83.13 $\pm$ 1.24
	S_3	120	81.05 $\pm$ 1.43
AFC group	A_1 (≤ 1200 d)	54	83.87 $\pm$ 2.14
	A_2 (1201-1500)	77	84.76 $\pm$ 1.75
	A_3 (1501-1800)	120	80.54 $\pm$ 1.41
	A_4 (1801-2100)	72	84.73 $\pm$ 1.85
	A_5 (> 2100 d)	61	81.18 $\pm$ 2.05

No effect was significant. See Table 3.

Table 3: Analysis of variance for breeding efficiency by the two methods

Source of variation	df	F (Tomar)	F (Wilcox)	Tabulated F
Period of calving	4	3.530**	2.204 NS	2.396 ($p < 0.05$); 3.370 ($p < 0.01$)
Season of calving	2	1.571 NS	1.651 NS	3.020 ($p < 0.05$); 4.662 ($p < 0.01$)
AFC group	4	78.640**	1.446 NS	2.396 ($p < 0.05$); 3.370 ($p < 0.01$)
Error	373			

** $p < 0.01$; NS = not significant. Error degrees of freedom 373 in every case.

Table 4: Heritability (h^2) and repeatability (R) estimates with standard errors for production and reproductive traits in Holdeo cows

Trait	$h^2 \pm SE$	$R \pm SE$	$h^2 - R$
LMY	-0.0539 ± 0.0312	-0.0439 ± 0.0237	-0.0100
PMY	-0.0539 ± 0.0220	-0.0439 ± 0.0191	-0.0100
DRPMY	-0.0540 ± 0.0143	-0.0440 ± 0.0120	-0.0100
LL	-0.0537 ± 0.0202	-0.0437 ± 0.0175	-0.0100
DP	-0.0540 ± 0.0410	-0.0440 ± 0.0311	-0.0100
SP	-0.0540 ± 0.0172	-0.0440 ± 0.0143	-0.0100
GP	-0.0583 ± 0.0331	-0.0483 ± 0.0225	-0.0100
CI	-0.0540 ± 0.0271	-0.0440 ± 0.0178	-0.0100

Note that $h^2 - R$ is exactly -0.0100 for all eight traits and that seven of the eight heritability estimates lie within 0.0003 of one another. See Results and Discussion.

Table 5: Correlations among production traits and breeding efficiency in Holdeo cows

Trait	LMY	PMY	DRPMY	LL	DP	BE
LMY	-	-0.715^{**}	0.148	-0.668^{**}	0.285^{**}	0.169
PMY		-	0.119	0.225^*	0.224^*	-0.135
DRPMY			-	0.239^*	0.247^*	-0.048
LL				-	0.285^{**}	0.255^{**}
DP					-	0.609^{**}
BE						-

** $p < 0.01$; * $p < 0.05$; coefficients without an asterisk are not significant. LMY = lactation milk yield; PMY = trait recorded as peak milk yield; DRPMY = days required to attain peak milk yield; LL = lactation length; DP = dry period; BE = breeding efficiency by the Tomar method.

Table 6: Breeding efficiency and genetic parameters of Holdeo cattle compared with published values

Comparison	Holdeo	Published	Source	Difference
BE, Tomar (1965) ^[22] method	72.55%	98.14%	Raina <i>et al.</i> (2016) ^[16] ; Singh <i>et al.</i> (2016) ^[14]	-25.59 points
BE, Wilcox (1957) ^[21] method	83.02%	82.31%	Raina <i>et al.</i> (2016) ^[16] ; Singh <i>et al.</i> (2016) ^[14]	$+ 0.71$ points
Age at first calving	1642 d	1020 d (Tomar optimum)	Tomar (1965) ^[22] formula	$+ 622$ d
h^2 , lactation milk yield	-0.0539	0.19 ± 0.03	Worku <i>et al.</i> (2021) ^[19] , Karan Fries	—
h^2 , calving interval	-0.0540	0.06 ± 0.01 ; 0.222 ± 0.101	Worku <i>et al.</i> (2021) ^[19] ; Vinothraj <i>et al.</i> (2016) ^[16]	—
h^2 , peak yield	-0.0539	0.405 ± 0.023	Deshpande and Bonde (1981) ^[3]	—

Published breeding efficiency values are for crossbred cattle at an organised dairy farm.

Conclusion

Breeding efficiency in Holdeo cattle averaged 72.55 ± 0.44 percent by the Tomar (1965) ^[22] method and 83.02 ± 0.82 percent by the Wilcox (1957) ^[21] method. By the Tomar method it was affected by period of calving ($p < 0.01$) and very strongly by age at first calving group ($F = 78.64$, $p < 0.01$), falling from 85.73 ± 1.15 percent in cows calving first before 1200 days to 58.89 ± 1.10 percent in those calving after 2100 days, a loss of 0.75 percentage points for every month of delay. By the Wilcox method no effect was significant, because age at first calving does not enter that formula.

Compared with published crossbred herds the Holdeo cows matched the Wilcox benchmark almost exactly, 83.02 against 82.31 percent, but fell 25.59 percentage points short of the Tomar benchmark. The shortfall lies entirely in age at first calving and not in the calving intervals the cows completed. Reducing age at first calving towards 30 months is therefore the single change that would do most for reproductive efficiency in this herd.

Heritability and repeatability estimates for all eight traits were negative, differed from one another by less than

0.0005 in seven of eight cases, and differed from their repeatability counterparts by exactly 0.0100 in every trait. These features indicate a computational artefact rather than independent estimates, and the correlations computed from the same analysis should be treated as preliminary. Of those correlations, the absence of any significant association between breeding efficiency and lactation milk yield is the one that carries a clear practical message: reproductive performance in Holdeo cattle will not improve as a consequence of selection for milk production.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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