672. The rising popularity of embryo transfer in U.S. dairy cattle and implications for national fertility evaluations

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Abstract

This research was motivated by the exponential increase in embryo transfer (ET) use with >5 times as many ET calves born in the U.S. in 2021 compared to just 5 years earlier. A survey of the national database revealed that only 1% of ET calves correspond to ET breeding events, 2% are incorrectly reported as artificial insemination, and 97% have no associated breeding event. Herdyears reporting >10% of calves born by ET but less than half of the expected number of ET breeding events were removed, and sire conception rate recalculated with this new dataset. Subsequent analysis showed that censoring herdyears with inconsistent ET reporting has little effect, except in the case of elite young bulls popular for ET use. Improved ET reporting will be critical for providing accurate fertility evaluations, especially as the popularity of these advanced reproductive technologies continues to rise.

Introduction

Commercial embryo transfer (ET) began in the 1970s and today has become common practice in herds desiring to increase their rate of genetic progress (Hasler 2014; Moore and Hasler 2017). Part of the attraction of ET can be explained by substantially reduced generation intervals among habitual ET users. For example, consider a top genetic merit heifer whose embryos were collected starting at 7 months old (Table 1). The maternal line continued this rapid turnover resulting in a remarkable 7 generations in 10 years (average generation interval 16.7 months). Embryos purchased in high enough volumes could cost as little as $125 per embryo, putting ET at a comparable price level to artificial insemination (AI) services (Trans Ova, personal communication). As transfer technologies become more affordable, ET use has grown exponentially with 11% of U.S. dairy calves born in 2021 attributable to ET (Figure 1). However, the trend in ET breeding event reporting (red line) does not parallel the ET calf birth rate (blue line) and this lack of congruence can interfere both with national evaluations and on-farm management of fertility. This discrepancy could be explained by a number of things, including embryo donation or implantation not being reported at all or ET being incorrectly reported as AI. Some of these errors can be eventually corrected when breed associations provide pedigree records, but they arrive 9 months too late as unofficial fertility evaluations are provided to U.S. producers on a weekly basis. Previously, the USA imposed edits for ET donors and reported recipients in our evaluations, and only 3 Interbull-participating countries account for ET by excluding ET records (Interbull Centre, 2021). Completely censoring ET-associated records is not necessarily the desired approach, as these represent the most elite animals and herds, and unreported ET could also bias fertility trait evaluations in the population. In this paper we propose an edit to account for incorrect ET reporting and explore its impact on sire conception rate (SCR), as an example.

Table 1. Maternal line and genotyped embryo of dam HOCAN13913420.

	Maternal generation							
	0	1	2	3	4	5	6	7
Birth year	2022	2020	2019	2018	2016	2015	2013	2012
Birth month	3	11	6	3	11	6	12	6
Age at embryo donation (months)	--	7	8	6	7	8	9	9
Generation interval[1]	16	17	15	16	17	18	18	--

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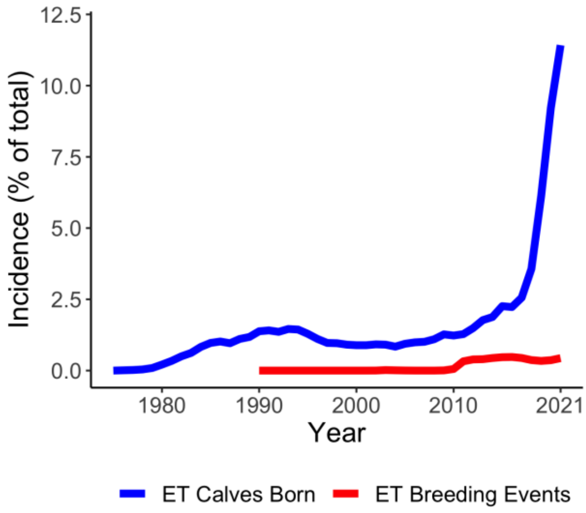

Figure 1. ET use in the USA.

Materials & methods

Data were extracted from the National Cooperator Database maintained by the Council on Dairy Cattle Breeding in December 2021, representing the most current information available on ET use in the USA. Reported mating types were matched with recorded birth types to assess ET reporting error rates. A new dataset was created by removing herdyears that reported >10% of calves born by ET but less than half of the expected ET breeding events given the number of ET calves born. This edit maximizes data preservation while removing the records most likely to introduce confounding bias. All summaries were performed in SAS version 9.4 (SAS Institute, Cary NC, USA) and data visualization performed with R version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria). This new dataset was used to compute SCR with the same methodology used for the official evaluations. SCR is computed with an all-breed animal model, including Ayrshire, Brown Swiss, Guernsey, Holstein, Jersey, and Milking Shorthorn, and using only the most recent 4 years of data (Council on Dairy Cattle Breeding, 2021). Pearson correlation coefficients between the new and old values were calculated, and the differences in SCR (SCR_{DIFF}) were computed for each bull by subtracting the official values from the new values generated with the proposed edit.

Results

For calves born by ET, breeding events reported 9 months earlier revealed only 1% of recipients correctly reported as ET, 2% incorrectly reported as AI, and 97% with no breeding event reported at all. The ET edit resulted in the removal of 252 herdyears for SCR, accounting for a 1.2% reduction in the total number of records included in the calculations. The number of publishable bulls was reduced for all breeds except Milking Shorthorn, which do not appear to be utilizing ET and only have one publishable bull (Table 2). The median SCR_{DIFF} is close to zero for all breeds and the biggest changes were observed in Holstein bulls (range of -1.9 to 1.3). A wider spread in SCR_{DIFF} is observed among bulls more frequently used for ET (Figure 2A), though SCR_{DIFF} converges on zero as more matings are reported (Figure 2B). ET usage is not strongly correlated with total number of matings, as many of the highest merit young bulls with comparatively few matings are now being used almost exclusively for ET (Figure 2C).

Table 2. Summary statistics of the impact of ET edits on sire conception rate.

		SCR_{DIFF} [2]				
	Publishable bulls[1]	Minimum	Median	IQR[3]	Maximum	Correlation[4]
Ayrshire	6 (7)	-0.3	-0.1	0.4	0.3	0.98*
Brown Swiss	44 (48)	-0.9	-0.1	0.3	0.6	0.99*
Guernsey	14 (17)	-0.6	0.1	0.6	0.6	0.96*
Holstein	1,379 (1,454)	-1.9	0.0	0.2	1.3	0.99*
Jersey	132 (141)	-1.4	-0.1	0.3	0.9	0.99*
Milking Shorthorn	1 (1)	0.0	0.0	0.0	0.0	--

[1] Publishable bulls with ET edit (publishable bulls without edit).
[2] Difference in SCR, computed as new values – old values.
[3] Interquartile range.
[4] Correlation between the new and old values. *P<0.0001.

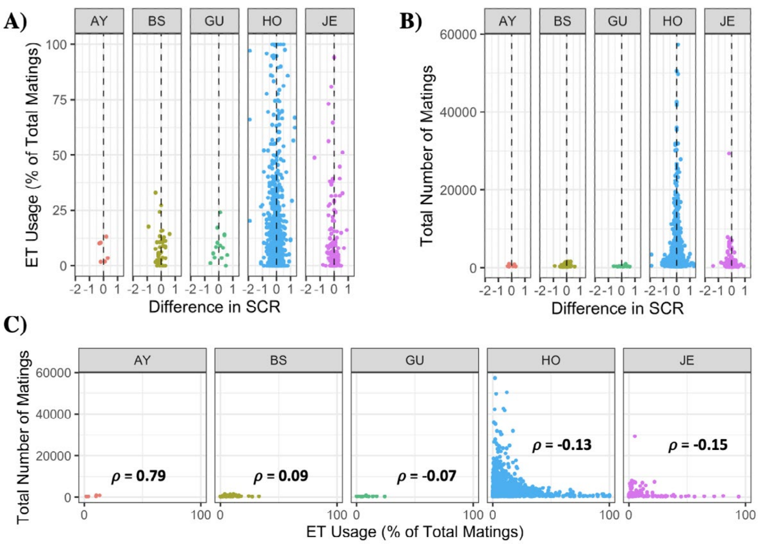

Figure 2. By-breed differences in SCR plotted against (A) percent of matings related to ET for each bull, (B) total number of matings for each bull, and (C) the correlation of total number of matings and popularity of each bull for ET. AY (Ayrshire), BS (Brown Swiss), GU (Guernsey), HO (Holstein), JE (Jersey), ρ = Pearson correlation coefficient.

Discussion

The new SCR computed from data filtered for ET was consistently highly correlated to the official values as shown in Table 2. The small effect of this edit can also be appreciated by examining the SCR_{DIFF} for individual bulls. The wider range of SCR_{DIFF} values among popular ET bulls was expected given that records were censored on the basis of ET usage. By plotting SCR_{DIFF} against the total number of reported matings for each bull, we see that as more records are added SCR_{DIFF} converges on zero, suggesting that the true effect of ET on SCR for proven bulls is nearly zero. This trend is most obvious in Holstein and Jersey, due to the larger amount of data available. It is notable that even for non-zeros, the difference is small (1-2 percentage points) and will have overall little effect. However, most breeds indicate a negative correlation between the total number of matings and the amount that bull is used for ET, suggesting that popular, proven bulls are not being prioritized for ET over young bulls. This explains anecdotal reports of young bulls whose SCR estimates may change a lot as more records are added or edited out, especially if their daughters are nearly all born by ET. Similar edits for unreported ET had larger effects on heifer conception rate than cow conception rate or SCR and might be needed for other fertility-related traits such as daughter pregnancy rate, gestation length, and early first calving. Acquiring high-quality ET records (comprising details like multiple ovulation ET versus *in vitro* fertilization, fresh versus frozen, embryo grade and stage, recipient synchrony, follicle stimulating hormone protocol, numbers of degenerate embryos, etc.) can help partition genetic effects among fertility, conception rate, and pregnancy rate. The Beef Improvement Federation recently approved guidelines for using ET records and necessary considerations in evaluation models, such as accounting for the effects of both the donor (e.g. calf genetics) and recipient (e.g. birth weight) dams. These principles could also be adopted by the dairy industry with the establishment of new data pipelines. Currently, unstandardized ET reporting is having minimal effect, but that is not a guarantee if the ET calf birth rate continues to rise without a parallel increase in accurate ET breeding event reporting.

Conclusions

The rapid increase of ET is likely to continue as advanced reproductive technologies become more affordable. An investigation of SCR shows that censoring herdyears without consistent ET reporting has overall negligible effect, except for young bulls. Even though the SCR correlations are high with small effects, the biggest changes are observed in elite new bulls which have a huge influence on the breeding program. There is an urgent need to improve ET reporting to facilitate the delivery of accurate fertility evaluations.

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