Cost-Benefit Analysis of Timed A.I. and Natural Service in Beef Cattle

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Introduction

Cattle breeders have long used natural service (NS) breeding (i.e., live bulls breeding cows as they naturally show heat), and it remains the predominant practice for most cow-calf producers. However, many cattle breeders have embraced the use of reproductive technologies such as artificial insemination (AI), estrus synchronization (ES) and embryo transfer (ET). The use of AI — more specifically timed AI (TAI; synchronized estrus to inseminate all cows in a group at the same time) — has garnered increased attention from seedstock and commercial producers over the past decade.

There are several reasons producers have adopted AI including:

- Access to genetics from sires that are cost prohibitive if purchasing a bull for natural service.
- Selecting genetics from multiple bulls to complement individual cows in the same mating group.
- Owning and managing fewer bulls.
- Narrowing the time frame of calving for the herd.

TAI has been widely adopted in beef production because it offers the benefits of AI, while reducing and concentrating the quantity of labor related to estrous detection ("checking heat"). Moreover, the modern ES protocols for TAI can shorten the

calving season while increasing overall calving rate. Even with these positive attributes, and numerous other benefits, many producers still view TAI as cost prohibitive. Thus, it is imperative to compare the costs and benefits for both TAI and NS to determine which breeding program is the most ideal for a given scenario.

Given the production benefits from TAI mentioned above, a clear indication of whether the production benefits exceed additional costs should be reached before deciding to implement this breeding technology in an operation. The objective of this paper is to compare the costs and revenues resulting from TAI against the costs and revenues resulting from NS breeding systems. These attributes will be compared across different size operations and across the typical range of pregnancy rates expected from application of a single TAI to begin the breeding season.

Factors to Consider

When comparing TAI against NS, it is important to consider the potential for:

1) Increased costs
2) Reduced revenue

vs.

3) Increased revenue
4) Reduced costs

Increased costs are the most obvious and often first-considered factor. There are obvious costs associated with implementing TAI that are not incurred for natural mating including pharmaceuticals, semen, labor and technician fees, in many instances. Increased revenue may stem from heavier calves at weaning and the ability to market larger groups of uniform animals that generally receive a higher price compared to marketing one animal at a time. Revenue can be reduced when there are fewer cull bulls to sale, but this also factors into the reduced cost category if fewer bulls must be maintained following TAI.

Specific factors that influence the cost and benefit of TAI include bull purchase price, pregnancy rate from TAI, annual ownership costs of a bull, useful life of a bull, salvage value of a bull, herd size, and production differences between TAI- and NS-sired calves. For this analysis, assumptions made for bulls are that annual ownership cost is $800; useful life is four years; and salvage value is $1,400. The production difference between TAI and NS is assumed to be a 4 percent increase in weaning weight for the calves sired by AI (Steichen et al. 2013) and 2 pounds per day for each day increase in calf age. Factors that fluctuate include bull purchase price, pregnancy rate from TAI and herd size.

Cost of Owning a Bull and TAI

Given that NS continues to be the predominant method of breeding cows, it is important for cattle producers to understand the total annual cost of owning a bull. The total annual cost of owning a bull includes the purchase price, the salvage value, number of breeding seasons it is used, annual carrying cost, risk of injury or death loss, and interest on the investment. **Table 1** outlines the total annual cost of carrying a bull with an initial purchase price of $4,000 and compares that to a bull with an initial purchase price of $6,000. Given the annual ownership cost of $800 and a $1,400 salvage value, the total annual cost of a bull purchased for $4,000 and used for four breeding seasons is $1,628. The total annual cost of a bull purchased for $6,000 is $2,206. The total cost per pregnancy is dependent on the number of cows exposed to the bull and the percentage of cows that conceive.

Table 1. Annual Bull Cost by Initial Bull Price

	Cost	Cost
Purchase price of bull ($/hd)	$4,000	$6,000
Weight of bull at salvage (lb/hd)	1,800	1,800
Salvage sale price ($/lb)	$0.80	$0.80
Salvage value ($/hd)	$1,440	$1,440
Number of breeding seasons (years)	4	4
Annual bull death loss (%)	1%	1%
Interest rate (%)	6%	6%
Annual carrying cost ($/hd)	$800	$800
Annual bull ownership cost ($/hd)	$828	$1,406
Total annual bull cost ($/hd)	$1,628	$2,206

The cost of TAI is more straightforward because most of the costs are experienced as cash costs each year. **Table 2** contains information on the cost of using TAI when the estrus synchronization protocol requires cattle to make three trips through the chute (i.e., 7-day CIDR + Co-Synch protocol). The cost of TAI includes one injection of prostaglandin (PG), two injections of gonadotropin-releasing hormone (GnRH), one controlled internal drug release (CIDR) insert, one straw of semen, breeding charge, and the labor of running cattle through the chute three times. Based on the protocol assumed in this analysis, it costs approximately $54.75 per cow that goes through the protocol for a 30-cow herd. The breeding charge is assumed to be reduced by $3 per head when breeding larger herds, which is a cost of $51.75 per cow. The total cost of TAI per pregnancy is dependent on the number of females that conceive via TAI.

Table 2. Itemized Costs of Timed Artificial Insemination

Item	Unit	Price ($/unit)	Total ($/hd)
Prostaglandin (PG)	1	3.50	3.50
Gonadotropin-Releasing Hormone (GnRH)	2	3.00	6.00
Controlled Internal Drug Release (CIDR)	1	13.00	13.00
Semen	1	20.00	20.00
Breeding charge	1	10.00	10.00
Labor (hours)	0.15	15.00	2.25
	Total cost per cow		54.75

[a] Breeding charge is assumed to be $7 per head for the 75- and 150-cow herd size, resulting in a breeding charge of $51.75 per cow.

Breeding Cost Comparison

When trying to determine if using TAI could benefit an operation, one should compare the cost of NS breeding alone with one round of TAI followed by NS bulls to breed cows that did not conceive during the TAI. The most important number to focus on for this comparison is the cost per pregnancy, because this value depicts the total cost of the value that produced by each breeding system. Breeding cost is dependent on the bull-to-cow ratio, cost of NS bulls, cost of TAI, herd size and the expected pregnancy rate from TAI, which influences the total number of NS bulls needed. **Table 3** contains a cost comparison of three herd sizes (30, 75 and 150 cows), two TAI conception rates (45 and 60 percent) and two bull purchase prices ($4,000 and $6,000). The analysis assumes a bull-to-cow ratio of 1 to 30 and a final pregnancy rate of 95 percent.

Given these assumptions, a producer with 30 cows requires one bull regardless of whether they use NS or if they include TAI. Moreover, the TAI pregnancy rate does not affect the number of bulls needed. However, a producer with a herd of 75 cows would require three NS bulls with a bull-to-cow ratio of 1 to 30. Therefore, incorporating TAI can reduce the number of NS bulls to two if a 45 percent conception rate is achieved with TAI and one bull if a 60 percent conception rate is achieved through TAI. Similarly, a producer with 150 breeding females would need five bulls if only using natural NS, but that is reduced to three bulls if a 45 percent TAI conception rate is achieved and two bulls if a 60 percent TAI conception rate is achieved.

30-Cow Herd Cost

Considering a bull purchase price of $4,000, the total breeding cost per pregnancy using NS is $57.14 per head, while the total breeding cost per pregnancy for both TAI conception rates analyzed is $114.77 per head. The cost per pregnancy for both TAI pregnancy rates is the same because the same number of NS bulls is needed in all scenarios. When the bull purchase price is increased to $6,000, the total breeding

cost per pregnancy in each scenario is increased by $20.25 per head to $77.39 for NS and $135.02 for TAI+NS 45 percent and TAI+NS 60 percent. Thus, the use of TAI in conjunction with NS in the 30-cow breeding herd increased breeding cost by more than $57 per head compared to using NS alone.

75-Cow Herd Cost

The total breeding cost per pregnancy using NS with a bull purchased for $4,000 is $68.57. The NS breeding cost in the 75-cow herd is higher than that of the 30-cow herd because the bull-to-cow ratio ends up being 1 bull to 25 cows instead of 1 to 30. The total breeding cost per pregnancy for TAI+NS 45 percent and TAI+NS 60 percent is $100.19 and $77.33, respectively. The TAI+NS 60 percent scenario results in a breeding cost that is about $9 per head more expensive than NS only because it reduces the NS bull needs to one bull.

Considering a bull purchase price of $6,000, the breeding cost per pregnancy when only using NS is $92.87, while the cost of TAI+NS 45 percent and TAI+NS 60 percent is $116.39 and $85.43, respectively. The higher bull purchase price results in the breeding cost of TAI+NS 60 percent being $7.44 per pregnancy less expensive than NS alone.

150-Cow Herd Cost

The cost of NS breeding in the 150-cow herd is the same as in the 30-cow herd, which is $57.14 with a bull purchase price of $4,000 and $77.39 with a bull purchase price of $6,000. Similarly, TAI+NS 60 percent resulted in the same breeding cost per pregnancy for the 150-cow herd as the 75-cow herd, which is $77.33 with a bull purchase price of $4,000 and $85.43 with a bull purchase price of $6,000. The total breeding cost per pregnancy for TAI+NS 45 percent and a $4,000 bull purchase price is $88.76 and $100.91 when the bull purchase price is $6,000.

TAI+NS 60 percent increased breeding cost per pregnancy by $20.19 compared to NS breeding when the bull purchase price was $4,000. When the bull purchase price was $6,000, the cost of TAI+NS 60 percent only increased breeding cost $8.04 per pregnancy compared to NS.

Table 3. Cost Per Cow Pregnancy Based on Herd Size, TAI Conception Rate and Natural Service Bull Purchase Price

Herd size (# of breeding females)	30			75			150		
Timed AI conception rate (%)	NS	TAI+NS[a] 45%	TAI+NS 60%	NS	TAI+NS 45%	TAI+NS 60%	NS	TAI+NS 45%	TAI+NS 60%
Total cost of AI ($)	--	1642.50	1642.50	--	3881.25	3881.25	--	7762.50	7762.50
Total cost per AI pregnancy ($)	--	121.67	91.25	--	115.00	86.25	--	115.00	86.25
Number of natural service bulls[b]	1	1	1	3	2	1	5	3	2
Bull purchase price ($/hd)	4,000								
Annual bull cost per female exposed ($)[c]	54.28	54.28	54.28	65.14	43.43	21.71	54.28	32.57	21.71
Total breeding cost per cow pregnancy ($)[d]	**57.14**	**114.77**	**114.77**	**68.57**	**100.19**	**77.33**	**57.14**	**88.76**	**77.33**
Bull purchase price ($/hd)	6,000								
Annual bull cost per female exposed ($)[c]	73.52	73.52	73.52	88.23	58.82	29.41	73.52	44.11	29.41
Total breeding cost per cow pregnancy ($)[d]	**77.39**	**135.02**	**135.02**	**92.87**	**116.39**	**85.43**	**77.39**	**100.91**	**85.43**

[a] Timed artificial insemination and natural service.

[b] Bull-to-cow ratio of 1:30 after accounting for TAI conception rate.

[c] Calculated from Table 2.

[d] 95 percent pregnancy rate.

Return to Breeding Cost Comparison

Not only is the cost of TAI a consideration, but producers have to compare expected returns to TAI. In this analysis, it was assumed producers marketed calves at weaning with an average calf weaning weight of 524 pounds for NS herds. AI-sired calves were assumed to have a 4 percent weaning weight advantage over NS-sired calves due to improved genetics (Steichen et al. 2013). Additionally, the use of TAI changes the calving distribution, which results in calves being older, on average, at weaning and thus a heavier average weaning weight (**Table 4**). A factor of 2 pounds per day was added to the weaning weight, based on the average calf age at time of weaning, given the calving distribution in **Table 4**. The calf price used in all scenarios was $130 per hundredweight. It was assumed the ability to market calves in larger and more uniform groups would offset the price slide from having a heavier average calf weight from AI-sired calves (Burdine, 2011). These conservative estimates may be underselling the use of TAI since producers could select bulls that lead their breed for weaning weight, which could provide more weaning weight advantage than assumed here, as well as underselling the group size and quality of calf price impact from TAI. Additionally, the improved value of replacement heifer quality and ability to more effectively manage heterosis brought by TAI are not factored into this analysis.

Table 4. Calf Weaning Weight Based on Calving Distribution, Days of Age and Genetic Merit

Calving Distribution	NS	TAI+NS[a] 45%	TAI+NS 60%
First 30 days	40%	45%	60%
30-60 days	35%	40%	30%
60-90 days	25%	15%	10%
Average weaning weight (lb/hd)[bc]	524	543	559

[a] Timed artificial insemination and natural service.
[b] Calf weaning weight is assumed to increase 2 lb/day, based on calf crop average age. AI-sired calves are 4 percent heavier due to genetics (Steichen et al. 2013).
[c] Weaning weight does not account for the estrous synchronization program helping cows to conceive earlier via NS.

Table 5 provides net returns to breeding cost by the scenarios analyzed. Given that NS calves were assumed to be weaned with an average weight of 524 pounds, calves in the TAI+NS 45 percent and TAI+NS 60 percent scenarios were assumed to have an average weaning weight of 543 pounds and 559 pounds, respectively. The average weights and uniform price across all scenarios resulted in total revenue of $681.20, $706.36 and $726.44 per head for NS, TAI+NS 45 percent and TAI+NS 60 percent, respectively.

30-Cow Herd Return

The return to breeding cost when using NS alone is $624.06 per head with a bull purchase price of $4,000 and $603.81 per head with a bull purchase price of $6,000. These values are $32.48 per head higher than TAI+NS 45 percent and $12.39 per head higher than TAI+NS 60 percent. NS would appear to have the highest return to breeding cost with this scenario. This is largely because there is no reduction in the number of NS sires. If production benefits from TAI are greater than what are assumed in this analysis, then TAI may still be feasible for this size operation.

75-Cow Herd Return

The return to breeding cost when using NS alone is $612.63 per head with a bull purchase price of $4,000, which is $6.46 per head more than TAI+NS 45 percent. However, the return to TAI+NS 60 percent is $36.48 more per head than NS. Similar results can be found with a bull purchase price of $6,000. Returns to NS breeding is $588.33 per head, which is $1.64 per head less than TAI+NS 45 percent and $52.68 less than realized returns TAI+NS 60 percent. Thus, the scenario where a 60 percent conception rate from TAI is assumed is the most profitable scenario with a 75-cow herd size. The benefit primarily comes from reducing NS sires from three bulls to one bull.

150-Cow Herd Return

Using NS and a $4,000 bull purchase price, the return to breeding cost is $624.06 per head, which is $6.46 per head greater than TAI+NS 45 percent and $25.05 less than TAI+NS 60 percent. The return to NS breeding cost assuming a $6,000 bull purchase price is $603.81 per head, which is $1.64 per head less than TAI+NS 45 percent and $37.20 less than TAI+NS 60 percent.

Table 5. Net Return to Breeding Cost

Herd size (# of breeding females)	30			75			150		
Timed AI conception rate (%)	NS[a]	TAI+NS[a] 45%	TAI+NS 60%	NS	TAI+NS 45%	TAI+NS 60%	NS	TAI+NS 45%	TAI+NS 60%
Average calf weaning weight (lb)[b]	524	543	559	524	543	559	524	543	559
Calf sale price ($/cwt)[c]	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00	130.00
Calf revenue ($/hd)	681.20	706.36	726.44	681.20	706.36	726.44	681.20	706.36	726.44
Bull purchase price ($/head)	4,000								
Total breeding cost per cow pregnancy ($)[d]	57.14	114.77	114.77	68.57	100.19	77.33	57.14	88.76	77.33
Net return to breeding cost	**624.06**	**591.58**	**611.67**	**612.63**	**606.17**	**649.11**	**624.06**	**617.60**	**649.11**
Bull purchase price ($/hd)	6,000								
Total breeding cost per cow pregnancy ($)[d]	77.39	135.02	135.02	92.87	116.39	85.43	77.39	100.91	85.43
Net return to breeding cost ($/hd)	**603.81**	**571.33**	**591.42**	**588.33**	**589.97**	**641.01**	**603.81**	**605.45**	**641.01**

[a] Timed artificial insemination and natural service.
[b] Calf weaning weight is assumed to increase 2 lb/day, based on calf crop average age. AI-sired calves are 4 percent heavier due to genetics (Steichen et al. 2013).
[c] The same price is used in all systems, as the lot size advantage from TAI is expected to offset the price slide (Burdine, 2011).
[d] Calves marketed is equal to calves born.

Conclusion

TAI is becoming more common among commercial cow-calf producers because it can reduce the number of NS bulls needed to breed females, shorten the calving season and provide superior genetics that would be cost prohibitive if purchasing a similar bull for NS breeding. Based on the assumptions in this brief analysis, one can see where advantages may exist when utilizing TAI as part of a breeding program. This analysis was conservative as it relates to the production advantages of TAI, which means the analysis may undersell how advantageous TAI could be in a commercial cow-calf operation. More specifically, this analysis did not account for the estrous synchronization process assisting in getting cows bred earlier if they failed to become pregnant via TAI. Similarly, this analysis did not account for selecting extremely superior bulls for AI nor did it account for heterosis that could be achieved or genetically superior heifers from AI.

This analysis includes TAI conception rates of 45 percent and 60 percent. Realized conception rates could be worse or better than the rates used in this analysis, which could leave a producer either extremely disappointed or encouraged. The variability of conception rates points to the importance of identifying a breeding technician that is known to have a good success rate and to closely follow a TAI protocol.

The use of TAI may not fit into every operation's management system because it does require more labor during the breeding season. A producer should carefully evaluate the advantages and disadvantages of each reproductive management system to determine if TAI would be beneficial.

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