WHEN TO USE SEXED SEMEN ON HEIFERS

Victor E. Cabrera
University of Wisconsin, Madison

INTRODUCTION

The terms gender-biased and sexed semen are used interchangeably in this paper. These refer to sexed-sorted semen (using the Beltsville method, Seidel and Garner, 2002) with the purpose of increasing the proportion of X-chromosome-bearing sperm and consequently to produce a higher proportion of females calves.

Gender-biased or sexed semen is relatively a new technology that has proven to produce a higher proportion of female calves than conventional semen (DeJarnette et al., 2009). Because female calves are more valuable than male calves, the use of sexed semen is economically attractive, although the insemination with sexed semen compromises fertility (DeJarnette et al., 2009). Consequently, sexed semen would have an increased proportion of females with a lower conception rate (**CR**). In addition to sex ratios and CR, there are a number of other factors that impact the economics of sexed semen reproductive programs. Therefore, the decision of where to use sexed semen should be an economic one based on a careful analysis of the balance between additional expenses and potential revenues.

Sexed semen could be used with any open dairy cattle in reproductive status, but because of the higher costs and potential CR reduction, this seems to be more appropriated for virgin heifers (De Vries, 2009) which have naturally higher CR than adult cows. Indeed, several reports recommend the use of sexed semen on virgin heifers in good standing heat (Dejarnette et al., 2009; Sterry et al., 2009; Olynk and Wolf, 2007; Weigel, 2004). In a survey to Wisconsin dairy producers (n = 347), the majority of producers were using sexed semen with virgin heifers during the first and second services (Sterry et al., 2009). However, it has also been reported that a number of producers are additionally experimenting the use of sexed semen with lactating cows and using it to expand their herd from within or to get more females from their best cows (Sterry et al., 2009; DeJarnette et al., 2009).

This paper analyzes the economic value of using sexed semen compared to using conventional semen on dairy virgin heifers. The methodology of analysis is partial budgeting of the survival curves for different reproductive strategies using net present value calculations.

MATERIALS AND METHODS

Calculating the Economic Value of Using Sexed Semen

Partial budgeting is a suitable method to analyze the economic benefits of using sexed semen on dairy heifers. Partial budgeting of testing a new technology tracks the additional revenues, the additional costs, the revenues foregone and the reduced costs, assuming all other economic conditions remain unchanged. Reproductive programs that include a series of services must include the aggregation of the above factors for each one of the services and because these services occur at different times, a fair comparison has to be performed using a discount rate to bring all balances to present values and then calculate and compare net present values (**NPV**). Under these premises, the economic value of a sexed semen reproduction protocol needs to be compared with conventional semen reproduction programs. Therefore, the economic evaluation should calculate the difference between a sexed semen protocol and a conventional unsexed semen protocol. If the difference is positive, the sexed semen has an advantage over the conventional semen. Assuming that producers will attempt up to 5 consecutive reproductive services on virgin heifers (Kuhn et al., 2006), the analysis included the economic value when sexed semen is used in 1, 2, 3, 4, or 5 consecutive services. Those services not using sexed semen use conventional unsexed semen.

In general, additional costs with sexed semen include a premium price for the semen dose and expenses due to more services to conception. The sexed semen brings additional value to the herd because of the differential value of additional heifers calves and associated cost reduction of potential cases of dystocia that are more prevalent with male calves. Consequently, the NPV was calculated as the aggregation of the discounted monetary values of successive reproductive services starting on a 14-mo old virgin heifer plus the discounted value of the probability of the heifer being culled and replaced if not pregnant after 5 consecutive services. Conditional reproduction probabilities were used to determine the CR and the probability of pregnancy and non-pregnancy after each one of the services.

The economic value (**EV**) of different reproduction programs for virgin heifers were then assessed as the difference between the NPV of sexed semen (X) programs and a conventional unsexed semen (NX) program, Equation 1.

$$EV = NPV(X) - NPV(NX) \quad [1]$$

The NPV of a reproductive program is the aggregation of the discounted monetary values of successive services s plus the discounted value of the probability of a heifer being culled and replaced if not pregnant after 5 services, Equation 2.

$$NPV = \sum_{s=1}^{5}(\delta_s)(NPV_s) + (\delta_5)(HC - HR)(1 - PP_5) \quad [2]$$

where δ is a discount rate, *HC* is the received heifer cull value (salvage value), *HR* is the calculated value of a 20-mo pregnant heifer and PP is the proportion of pregnant cows after the 5th service. The NPV after each service is:

$$NPV_s = CR_s^{'} * (CV - DC) - (1 - PP_s) * MC - AIC$$
[3]

where *CR'* is the conception rate achieved in service s, *CV* is the calf value calculated as the probability of female calf multiplied by the female calf value plus the probability of male calf multiplied by the male calf value, *DC* is the estimated dystocia cost, *MC* is the non-pregnant heifer maintenance cost and *AIC* is the cost of semen dose.

Conditional probabilities were used to determine the CR achieved (*CR'*) and the proportion of pregnant cows (*PP*) in each one of the services as indicated in Equation 4.

$$PP_1 = CR_1^{'} = CR_1$$
$$PP_s = PP_{s-1} + (1 - PP_{s-1}) * CR_s \text{ for s = 2 to 5} \quad [4]$$
$$CR_s^{'} = PP_s - PP_{s-1} \text{ for s = 2 to 5}$$

Reproductive Parameters

A baseline CR for conventional unsexed semen for US heifer Holsteins can be assumed to vary between 34 and 83 % (Average 56 %) (DeJarnette et al., 2009). Sexed semen would perform at 80 % of the unsexed conventional semen (DeJarnette et al., 2009). It has also been reported that the CR decreases with each additional service. The conventional and implied sexed CR would have a great influence in the EV. The CR may drop an absolute 2.5 % for each successive service after the first service (Kuhn et al., 2006) whether conventional or sexed semen is being used. A baseline heifer calf rate can be assumed to be 46.7 % with conventional semen (Silva del Rio et al., 2007) and 89 % with sexed semen (DeJarnette et al., 2009) (Table 1).

Economic Parameters

A baseline cost of unsexed conventional and sexed semen dose (*AIC*) can be set at $15 and $45, respectively (Olynk and Wolf, 2007), which indicates a premium of about $30 when using sexed semen compared with conventional unsexed semen.

Other parameters that are applied to conventional and sexed programs are described below. Although some of these are applied equally to both programs (conventional and sexed), these affect differently to conventional and sexed semen programs because of different CR and timing of distinct reproductive programs. As baseline, the female calf value can be considered to be $562 whereas the value of a male calf can be considered to be $48 (Wisconsin USDA Market report, 2008) (Table 2).

Dematawewa and Berger (1997) reported an overall cost of dystocia for primiparous cows of $28.53. This cost included approximately a 50 % chance of female and male calves and was computed as the associated costs of the risk of losing a cow and the risk of losing a calf by all dystocia incidence scores (1 to 5) according to Martinez et al. (1983). A higher dystocia incidence was associated with male calves than with female calves. Martinez et al. (1983) found that the overall ratio of dystocia was 1.57 times greater for males than for females calves. The cost of dystocia was then set to $34.91 for male born calves and to $22.15 for female born calves.

Table 1. Reproductive parameters of conception rate and heifer calf born with unsexed and sexed semen.

Heifer Reproductive Program	Conception Rate (CR) (%)	Female Calves (%)
Conventional Unsexed Semen	34.0 to 83.0, Avg. 56	46.7
Sexed Semen	27.2 to 66.4, Avg. 45	89.0

Table 2. Economic parameters of reproductive programs with virgin heifers using unsexed and sexed semen**.**

Economic Parameter	Unsexed Semen	Sexed Semen
Semen dose ($)	15	45
	Female Calf	**Male Calf**
Calf value ($)	562	48
Dystocia cost ($)	22.15	34.91
	Unsexed and Sexed Semen	
Heifer maintenance 15 to 20 mo old ($/d)	2.4	
Weight of a 20-mo non-pregnant heifer (kg)	505	
Salvage value of 20-mo non-pregnant heifer ($/kg)	1.79	
Value of 20-mo pregnant heifer ($)	1,200	
Interest rate (%/yr)	12	

The average cost of maintenance of non-pregnant heifers between 15 and 20 mo of age can be considered to be $2.4/d (Zwald et al., 2007). The average weight of a 20-mo non-pregnant heifer could be assumed to be 505 kg (NRC, 2001). The salvage value (cull) of a 20-mo non-pregnant heifer can be assumed to be $1.79/kg live weight and the replacement value of an equal weight pregnant heifer to be $1,200 (Wisconsin USDA Market report, 2008). Finally, an annual interest rate similar to the minimum charged by credit card companies of 12 % was used to calculate the discount rate (δ).

Analysis

The model was used to calculate the EV of sexed semen reproductive programs under different scenarios. First, the EV under baseline conditions is reported and discussed for low, average and high conventional CR for all reproductive strategies (1 to 5 sexed semen consecutive services). In order to compare different scenarios based on alternative biological and economic parameters, the concept of overall EV was introduced as the average EV for all the conventional CR considered (low, average and high conventional CR) and for all analyzed reproductive programs (1 to 5 sexed semen consecutive services). Subsequently, the conventional CR required to find a positive EV were studied as well as the sensitivity of the main biological and economic parameters.

RESULTS AND DISCUSSION

The Economic Value of Using Sexed Semen for Heifers

The use of sexed semen would always be economically justified when it is used in the first service for any level of conventional CR (Table 3) under the baseline biological and economic parameters. The economic value (EV) of a sexed semen program has a positive relationship with the already established conventional CR: this value is higher with higher CR. For the low CR scenario (34 %), the use of sexed semen is only justified for the 1 service as it would be negative with 2 or more services (Table 3). For an average CR (56 %), the use of sexed semen would be justified for up to 4 services and for the high CR (83 %), it would be justified for all 5 services. There is an interaction between CR, the number of services using sexed semen and the EV as the EV for 2 services becomes the maximum when the conventional CR is average (56 %) or high (83 %). When the conventional CR is low (34 %), 2 sexed semen services has a lower EV than 1 service.

Table 3. The economic value (EV) of sexed-semen reproductive programs over a conventional reproductive program and the minimum CR to justify the use of sexed semen for baseline biological and economic parameters of Tables 1 and 2.

Reproductive Program	Low Conventional CR (34 %)	Average Conventional CR (56 %)	High Conventional CR (83 %)	Required Conventional CR to Justify the Number of Sexed Semen Service(s)
		$/heifer		%
1 service with sexed semen	6.5	49.3	100.0	31
2 first services with sexed semen	-3.4	57.8	111.6	36
3 first services with sexed semen	-23.1	46.4	96.1	41
4 first services with sexed semen	-48.9	24.7	71.7	48
All 5 services with sexed semen	-78.5	-2.7	43.9	58

When the conventional CR is expected to be high (83 %), the use of sexed semen would bring between $44 (5 services) and $112 (2 services) of additional value per heifer. When the CR is expected to be average (56 %), the use of sexed semen would bring between $25 (4 services) and $58 (2 services) of additional value per heifer, but it would have a negative EV of -$3 if used in all 5 services. When the conventional CR is expected to be low (34 %), the use of sexed semen would yield the maximum and the only positive value of $7 for 1 service. For the other services the EV would always be negative between -$3 (2 services) and -$79 (5 services). The overall EV for all reproductive programs for baseline biological and economic parameters was calculated to be $30.10 per heifer.

The conventional CR at which the value of using sexed semen program was higher than the value of using the conventional semen when used for 1 service was 31 % (Table 3). Therefore, the use of sexed semen would only be justified for 1 sexed semen service if the expected conventional CR is 31 % or above. Similarly, in order to justify the use of sexed semen for 2, 3, 4, and 5 services, the conventional CR would have to be at least 36 %, 41 %, 48 % and 58 %, respectively (Table 3).

Sensitivity to Selected Biological Parameters

Sensitivity of Sexed Semen CR

As seen, the opportunity of using sexed semen on virgin heifers would be highly dependent on the expected CR with conventional semen. This is because the CR for sexed semen would normally be a function of that of the conventional CR (80 %; DeJarnette et al., 2009). However, when the sexed semen CR was set at 85 % of the conventional CR, the model showed a positive value for sexed semen for up to 2 services when low conventional CR and for all 5 services with average and high conventional CR. With sexed semen CR at 85 % of the conventional CR, the overall EV was $46.4 ($16.3 more than baseline). When the sexed semen CR was set at 75 % of the conventional CR, the value of sexed semen programs would only be positive for up to 4 services for average conventional CR and for all 5 services with high conventional CR. With a sexed semen CR at 75 % of the conventional CR, the overall EV was $12.5 ($17.6 lower than the baseline) (Table 4).

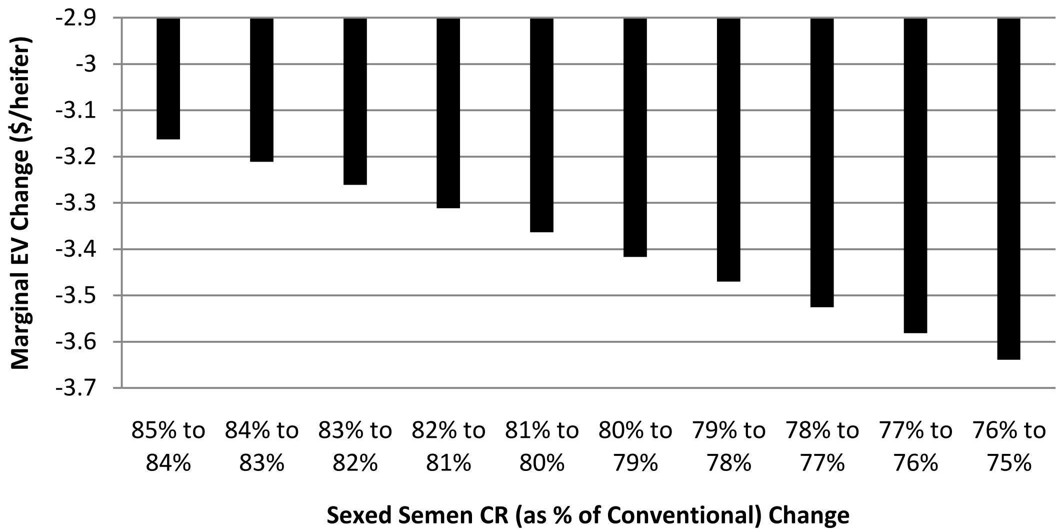

Figure 1. Marginal overall expected value (EV) to changes on sexed semen conception rates (CR) as a percentage of conventional CR.

If the sexed semen CR would be expected to be 85 % of the conventional CR, the use of sexed semen would be justified if the conventional CR is at least 26 %, 30 %, 35 %, 41 %, and 49 % for 1 to 5 services, respectively (between 5 and 9 % less than baseline results). If the sexed semen CR would be expected to be 75 % of the conventional CR, the use of sexed semen would be justified if the conventional CR is at least 36 %, 42 %, 48 %, 56 %, and 66 % for 1 to 5 services, respectively (between 5 and 8 % more than baseline results).

Figure 1 depicts the overall EV change (decrease) to decreasing expected sexed semen CR as a percentage of the conventional CR from 85 % to 75 %. One percentage decrease in the sexed semen CR as percentage of the conventional CR would decrease the overall EV between $3.2 and $3.6 per heifer. At lower sexed semen CR, the marginal EV decreases faster (i.e., $3.1 between 85 and 84 % and $3.6 between 76 and 75 %). The opposite is also true as at higher sexed semen CR, the marginal EV increases at a slower pace.

Sensitivity to Sexed Semen Sex Ratios

Although the percentage of female calves born from sexed semen programs in average is 89 %, this could vary between 78 and 95 % (DeJarnette et al., 2009). Setting up a sex ratio for heifer calves of 78 % resulted in substantial lower overall EV of -$10.9 ($41 lower than the baseline scenario) with what the opportunity of using sexed semen is only economically justified for up to 3 services with average conventional CR and up to 4 services with high conventional CR. With an 78 % heifer calves with sexed semen, the CR would need to be at least 41 % to justify the use of sexed semen for 1 service. However, setting up a sex ratio for heifer calves of 95 % resulted in substantial higher overall EV of $52.4 ($22.3 higher than the baseline scenario) with what the opportunity of using sexed semen increases to 2 services with low conventional CR and for all services for average and high conventional CR. With an 95 % heifer calves with sexed semen, the CR would only need to be 27 % to justify the use of sexed semen for 1 service (Table 4).

Sensitivity to Selected Economic Parameters

Sensitivity to Semen Cost

More important than the independent cost of a conventional and sexed semen dose is the difference in value between these two or the premium paid for the sexed semen. The calculations are insensitive to the same value increase or decrease in both conventional and sexed semen. However, they are highly sensitivity to a differential change between conventional and sexed semen. The analysis found that for each $1 in change in the premium on the sexed semen, the overall EV changed by $2.9. When a new technology such as sexed semen becomes more readily available, the premium for it would probably decrease and consequently the EV of using sexed semen would likely increase in years to come. To reach a positive EV for all scenarios (low, average and high conventional CR) and for

Table 4. Sensitivity analysis to selected biological and economic parameters.

Scenario	Overall Expected Value (EV)	Conventional CR to Justify 1 Sexed Semen Service	Number of Consecutive Services with Positive Expected Value (EV)		
			Low Conventional CR (34 %)	Average Conventional CR (56 %)	High Conventional CR (83 %)
	($/heifer)	(%)			
Baseline	30.10	31	1	4	5
Sexed Semen CR at 85 % of conventional CR	46.40	31	2	5	5
Sexed Semen CR at 75 % of Conventional CR	12.50	36	0	4	5
Sexed Semen to Have 95 % Heifer Calves	52.40	27	2	5	5
Sexed Semen to Have 78 % Heifer Calves	-10.90	41	0	3	4
Male Calf value at $0	45.20	28	2	5	5
Female Calf value at $700	69.30	25	3	5	5
Dystocia Cost at $42.8	32.40	30	1	5	5
Dystocia Cost at $14.27	27.70	31	1	4	5

all reproductive programs (1 to 5 sexed semen services), the premium for sexed semen needed to be $13 (instead of $30 as in the baseline scenario). For a premium of sexed semen of $13, the best number of services would be 3 for average (with an overall EV of $96) and for high (with an overall EV of $146) conventional CR, whereas the best number of services would be 2 for the low conventional CR (with an overall EV of $30).

Sensitivity to Calf Value

Although values assigned to male and female calves were based on market reports, these can be considered somehow arbitrary because not all producers sell their calves and probably most of them would keep most of the heifers. More important is then to try to assess the perceived calf value for a particular producer. For example some producers would consider a value of $0 for male calves. Also, depending on the farm's goals, female calves would have a higher than market perceived value (e.g., considerations of genetic improvement or herd expansion). Therefore, producers interested in sexed semen programs would likely perceive calves values differently than the market values. Setting the value of male calves to $0 (instead of $48 in the baseline scenario) improved the overall EV of the sexed semen programs to $45.2 ($15.2 higher than the baseline) suggesting up to 2 services with low conventional CR and all 5 services with average and high CR. When the male calf does not have a value for the producer, 1 sexed semen service would be justified even if the conventional CR is 28 %. Setting a value of $700 (instead of $562) for a female calf improved the overall EV of the sexed programs to $69.3 ($39.2 higher than the baseline) suggesting up to 3 services with low conventional CR and all 5 services with average and high conventional CR. With a female calf price of $700, 1 service of sexed semen would be justified even if the conventional CR is 25 % (Table 4).

Sensitivity to Dystocia Cost

The cost of dystocia would change constantly because of changes in values of cows and calves. Assuming a 50 % higher cost of dystocia ($42.8 instead of $28.5 in the baseline scenario) would increase the overall EV of the sexed semen programs slightly to $32.4 (2.34 higher than the baseline) suggesting 1 service with low conventional CR and all services with average and high conventional CR. With 50 % higher dystocia cost, it would be needed 30 % conventional CR to justify the use of sexed semen for 1 service. Assuming a 50 % lower cost of dystocia ($14.27 instead of $28.5 in the baseline scenario) would decrease the overall EV of the sexed semen programs slightly to $27.7 ($2.35 lower than the baseline) suggesting 1 service for low conventional CR, 4 services for average conventional CR and all 5 services for high conventional CR. With 50 % lower dystocia cost, it would be needed 31 % conventional CR to justify the use of sexed semen for 1 service (Table 4). As seen, the dystocia interaction with sexed semen would only have a limited impact in the EV and would not be preponderant in the decision of using or not using sexed semen.

Sensitivity to Other Assumed Costs

Analyses with the model revealed that for every $0.1 change in the 15 to 20 mo heifer maintenance cost (baseline set at $2.4/d), the overall EV of the sexed semen programs would change by $1 in the opposite direction (negative association); for every $0.1 change in the salvage value (baseline set at $1.79/kg), the overall EV of the sexed semen programs would change by $1.44 in the same direction (positive association); for every change in the value of a 20-mo pregnant heifer of $100 (baseline set at $1,200/heifer), the overall EV of the sexed semen programs would change by $2.84 in the opposite direction (negative association); and for every percentage point of annual interest change (baseline set at 12 %), the overall EV of the sexed semen programs would only change marginally in the opposite direction (marginal negative association).

CONCLUSIONS

In most of the situations, the use of gender-biased or sexed semen would have a higher economic value than the use of conventional semen. The single most important parameter to decide in the use of sexed semen is the current or expected virgin heifer CR with conventional semen, which will determine the CR attained with sexed semen. In general, if the conventional CR is between 31 % and 44 %, the use of sexed semen would bring additional economic value if used only in the first service. At higher conventional CR, the opportunity of using sexed semen in successive services would increase together with higher economic values realized. For a conventional CR between 45 % and 83 %, the highest economic benefit would be realized by using sexed semen in the 2 first services. The assumed biological (e.g., sexed semen CR, sexed semen sex ratios) and economic (e.g., semen costs, calf values, dystocia cost) parameters would influence the calculated expected values and consequently the decisions of using sexed semen. Consequently, these parameters should be defined on a particular basis and the analysis should be performed for farm specific conditions. An online decision support tool has been created with such purpose. The tool is freely available at: http://www.uwex.edu/ces/dairymgt/ under the section "Management Tools" with the title "Economic Value of Sexed Semen Programs for Dairy Heifers."

Some considerations that were not included in the economic analysis, but are important to remember in the light of using sexed semen include: some evidence of greater incidence of stillbirths, decreased bio-security risks, faster genetic improvement possibilities, and implications for herd expansion.

ACKNOWLEDGEMENTS

The author would like to acknowledge Paul Fricke for comments and feedback provided on an earlier version of this manuscript. Acknowledgent is also extended to Julio Giordano for providing farm specific data to test and validate the model presented in this paper.

LITERATURE CITED

DeJarnette, J. M., R. L. Nebel, and C. E. Marshall. 2009. Evaluating the success of sex-sorted semen in US dairy herds from on farm records. Theriogenology 71:49-58.

Dematawewa, C. M. B., and P. J. Berger. 1997. Effect of dystocia on yield, fertility, and cow losses and an economic evaluation of dystocia scored for Holsteins. J. Dairy Sci. 80:754-761.

De Vries, A. The economics of sexed semen in dairy heifers and cows. The Institute of Food and Agricultural Sciences (IFAS) Extension, University of Florida, AN 214. Gainesville.

Kuhn, M. T., J. L. Hutchinson, and G.R. Wiggans. 2006. Characterization of holstein heifer fertility in the United States. J. Dairy Sci. 89:4907-4920.

Martinez, M. L., A. E. Freeman, and P. J. Berger. 1983. Factors affecting calf livability for Holsteins. J. Dairy Sci. 66:2400-2407.

National Research Council (NRC). 2001. Nutrient requirements for dairy cattle. 7th Revised Ed. The National Academies Press, Washington DC.

Olynk, N.J., and C. A. Wolf. 2007. Expected net present value of pure and mixed sexed semen artificial insemination strategies in dairy heifers. J. Dairy Sci. 90:2596-2576.

Seidel, G. E., and D. L. Garner. 2002. Current status of sexing mammalia spermatozoa. Reproduction 124:733-743.

Silva del Rio, N., S. Stewart, P. Rapnicki, Y. M. Chang, and P. M. Fricke. 2007. An observational analysis of twin births, calf sex ratio, and calf mortality in Holstein dairy cattle. J. Dairy Sci. 90:1255:1264.

Sterry, R., D. Brusveen, V. E. Cabrera, K. Weigel, P. Fricke. Why they use sexed semen. Hoards Magazine, March 25, 2009, pg. 205.

Weigel, K. A. 2004. Exploring the role of sexed semen in dairy production systems. J. Dairy Sci. 87:(E. Suppl.):E120-E130.

Wisconsin USDA Market Report. 2008. Wisconsin cattle summary for the week ending Friday Oct 24, 2008. Available at: http://www.ams.usda.gov/mnreports/md_ls150.txt.

Zwald, A., T. L. Kohlman, S. L. Gunderson, P. C. Hoffman, and T. Kriegl. 2007. Economic costs and labor efficiencies associated with raising dairy herd replacements on Wisconsin dairy farms and custom heifer raising operations. UW Extension. Available at: http://www.uwex.edu/ces/cty/sheboygan/ag/dairy/documents/CostofRaisingHeifers-2007ICPAReport.pdf

Appendix:

Instructions of Use of the Online Tool "The Economic Value of Sexed Semen Programs for Dairy Heifers" Available at: http://www.uwex.edu/ces/dairymgt/: Management Tools: Economic Value of Sexed Semen Programs for Heifers.

To calculate the economic value of using sexed semen for heifers you need to define some reproductive, biological and economic parameters. For all input information you can enter information either using the provided spin buttons or writing numbers directly from your keyboard.

1. Conception rates
  - **a.** Conventional semen conception rate (CR; %). This is the percentage of heifers becoming pregnant after the first service with conventional semen. You can enter a low, an average and a high CR.
  - **b.** Sexed semen CR as a proportion of the conventional semen CR (%). This is the percentage of CR of sexed semen with respect to the conventional CR. The tool will automatically calculate the absolute value of CR when using sexed semen. Example: 80 % means that the sexed semen CR is 80 % of the conventional CR.

2. Expected females
  - **a.** Female calves with conventional semen (%). This is the percentage of male calves when conventional semen is used.
  - **b.** Females calves when using sexed semen (%). This is the percentage of female calves when sexed semen is used.

3. Semen cost
  - **a.** Estimated cost of conventional semen dose ($).
  - **b.** Estimated cost of sexed semen dose ($).

4. Economic parameters
  - **a.** Discount rate (%/yr). Interest rate to calculate the net present value.
  - **b.** Female calf value ($). Estimated market value of a female calf.
  - **c.** Male calf value ($). Estimated market value of a male calf.
  - **d.** Raising cost ($/day). Daily cost of maintaining a heifer between 15 and 20 months of age.
  - **e.** Salvage value ($/kg). Value of a heifer culled at 20 months of age with a weight of 1112 lb.
  - **f.** Replacement value of a 20-month pregnant heifer. Estimated market value of a 20-month pregnant heifer.

5. Interpret the economic value (EV; $) of sexed semen programs compared with a conventional semen program.
  - **a.** Figure presented shows the expected value (EV) of a reproductive program defined as the difference of the net present value (NPV) of sexed semen and conventional semen. Positive values (EV > 0) indicate that the sexed semen outperformed the conventional semen and negative values (EV < 0) indicate that the conventional semen outperformed the sexed semen.
  - **b.** In the Figure there are 3 groups of bars. Each group represents your defined conventional CR: low, average, high.
  - **c.** For your convenience, a box below each group of bars indicates the absolute value of conventional CR along with the calculated sexed semen CR used in the calculations.
  - **d.** In each group of bars, there are 5 different colors of bars, which represent the number of sexed semen services in each program. From left to right these are 1 (green), 2 (blue), 3 (red), 4 (brown), and 5 (orange) that represent 1, 2, 3, 4, and 5 sexed semen services, respectively.
  - **e.** The overall EV of a defined sexed program is calculated as the average of all EV displayed in the figure and is displayed in the right bottom corner of the figure.

6. Additional functionality by clicking provided buttons at the right top corner of the application.
   a. Instructions: Open this set of instructions in a new web browser
   b. Manage Scenarios: Save and retrieve input data for all parameters in the tool
   c. Print: Print your results
   d. DairyMGT Webpage: Return/visit the UW-Wisconsin Dairy Management Website

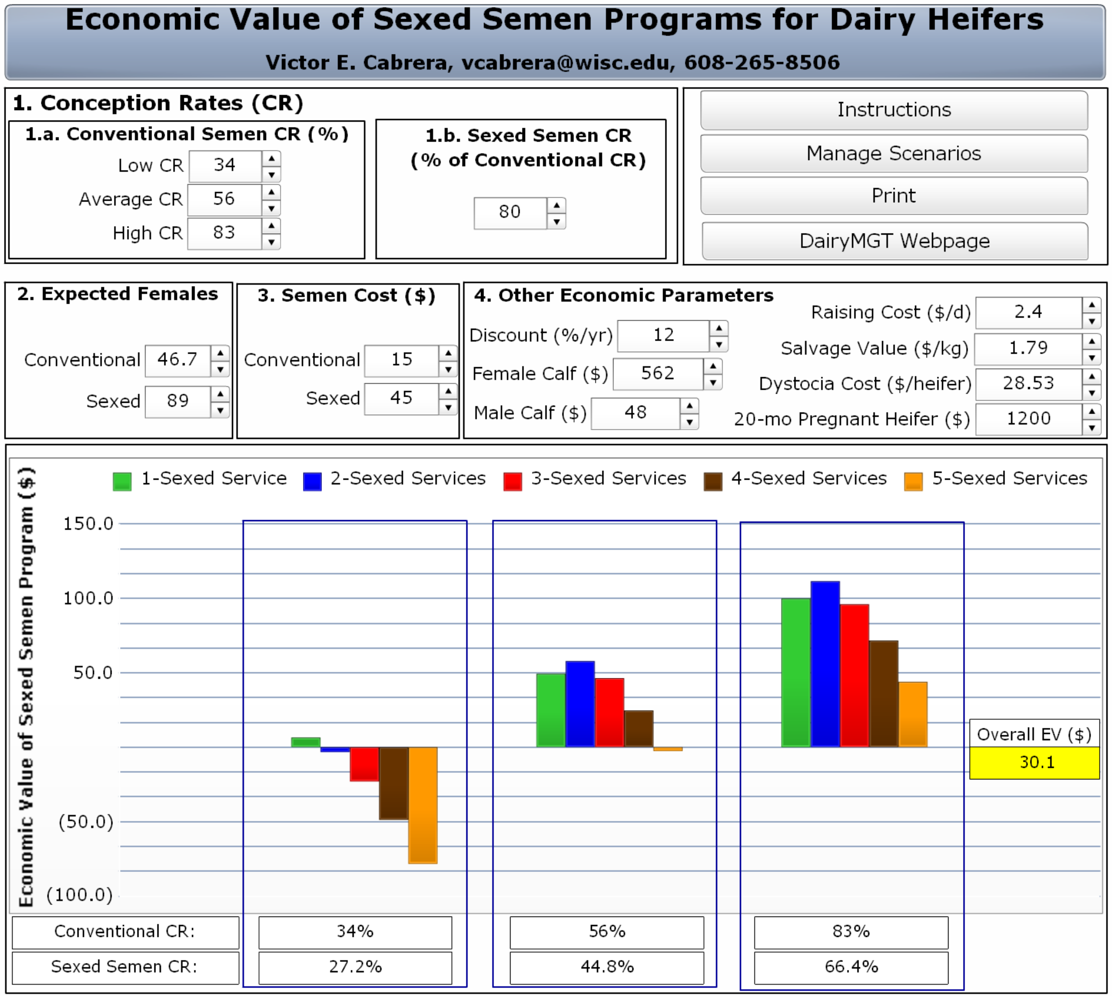

Figure A. Screenshot of "Economic Value of Sexed Semen Programs for Dairy Heifers" available at http://www.uwex.edu/ces/dairymgt/: Management Tools: Economic Value of Sexed Semen Programs for Heifers.