Associations between Age at First Calving and First Lactation Performance

Michael Overton, DVM, MPVM

USDBUNON02001

Three Big Drivers For Achieving A More Efficient And Profitable Earlier Age At First Calving:

- Nutritional management
  - Efficient and increased rate of gain
  - Achievement of puberty and adequate frame at earlier age with less variation
- Health management
  - Proper housing, vaccination, therapeutic and culling management are key
- Reproductive management
  - Less variation around time of first service
  - Improved pregnancy rates once breeding starts
  - An established, limited period of breeding

Knowledge Solutions

USDBUNON02001

Variables Affecting Replacement Costs

- First, cost can be evaluated on two levels:
  - Cost as a % of the herd's cost of production
  - Actual cost/heifer entering the herd
- Performance factors:
  - Morbidity, mortality, rate of gain, reproductive performance, age at first calving
- Management factors:
  - Breed, housing choice/ environment, nutritional strategy, labor, herd expansion plans, replacement needs
- Age at first calving and herd replacement rates are two of the largest factors affecting cost
  - Both impact the number of heifers needed
  - Age at first calving also has a large impact on cost/heifer
  - Reducing age at first calving by 1 month lowered cost of a replacement program by 4.3%[1]

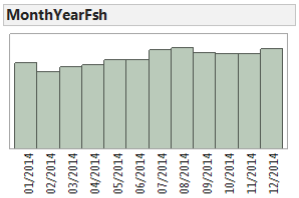
[1]Tozer & Heinrichs, 2001. *J. Dairy Sci.*, 84(8): 1836-1844.

USDBUNON01783

DDAS Date Set Analyzed in JMP 12.2

- Herds had >19,000 305M
- AGEFR = 19-30 months
- Calved in 2014

- 48 Holstein herds
- 65,202 first lactation cows



Frequencies

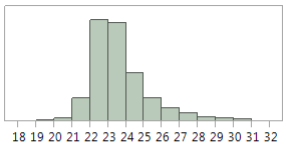
Level	Count	Prob
01/2014	5138	0.07880
02/2014	4580	0.07024
03/2014	4897	0.07511
04/2014	4975	0.07630
05/2014	5329	0.08173
06/2014	5323	0.08164
07/2014	5928	0.09092
08/2014	6022	0.09236
09/2014	5699	0.08741
10/2014	5678	0.08708
11/2014	5657	0.08676
12/2014	5976	0.09165
Total	65202	1.00000

Elanco | Knowledge Solutions

USDBUNON02001

Limited Data Set to Herds with >19,000 305M
AGEFR = 19-30 months

AGEFR



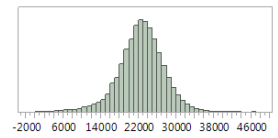
Quantiles

100.0%	maximum	30
99.5%		29
97.5%		27
90.0%		25
75.0%	quartile	24
50.0%	median	23
25.0%	quartile	22
10.0%		22
2.5%		21
0.5%		20
0.0%	minimum	19

Summary Statistics

Mean	23.096393
Std Dev	1.5213453
Std Err Mean	0.005958
Upper 95% Mea	23.10807
Lower 95% Mean	23.084715
N	65202

305M



Quantiles

100.0%	maximum	46670
99.5%		34250
97.5%		31400
90.0%		28230
75.0%	quartile	25580
50.0%	median	22800
25.0%	quartile	19950
10.0%		17000
2.5%		12420
0.5%		7480
0.0%	minimum	300

Summary Statistics

Mean	22645.932
Std Dev	4611.528
Std Err Mean	18.631106
Upper 95% Mea	22682.449
Lower 95% Mean	22609.415
N	61265

Elanco | Knowledge Solutions

USDBUNON02001

Milk Production: Milk90

Response Milk90

Summary of Fit

RSquare	0.216827
RSquare Adj	0.208857
Root Mean Square Error	1093.656
Mean of Response	6392.913
Observations (or Sum Wgts)	59162

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	596	1.9393e+10	32539403	27.2049
Error	58565	7.0049e+10	1196084	Prob > F
C. Total	59161	8.9442e+10		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Herd#	45	45	1.0858e+10	201.7257	<.0001*
MonthFsh[Herd#]	499	499	4754064208	7.9653	<.0001*
Calf Outcome M/F/Tw	2	2	394093283	16.4743	<.0001*
AGEFR	1	1	257576616	21.5350	<.0001*
AGEFR^2	1	1	160864152	13.4492	0.0002*
MastInFirst30DaysYN	1	1	325568890	272.1957	<.0001*
MetrInFirst30DaysYN	1	1	776203930	648.9544	<.0001*
DAInFirst30DaysYN	1	1	198543767	165.9948	<.0001*
Herd#*AGEFR	45	45	965991647	1.7947	0.0009*

AGEFR	Difference in Milk90 from Prev AGEFR
19	-
20	109
21	99
22	89
23	79
24	69
25	59
26	49
27	39
28	29
29	19
30	9

Elanco | Knowledge Solutions

USDBUNON02001

Milk Production: Milk90 (same model, but without disease data)

Response Milk90

Summary of Fit

RSquare	0.202014
RSquare Adj	0.193934
Root Mean Square Error	1103.923
Mean of Response	6392.913
Observations (or Sum Wgts)	59162

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	593	1.8069e+10	30469726	25.0030
Error	58568	7.1374e+10	12186449	Prob > F
C. Total	59161	8.9442e+10		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Herd#	45	45	1.0732e+10	195.6957	<.0001*
MonthFsh[Herd#]	499	499	4829064042	7.9412	<.0001*
Calf Outcome M/F/Tw	2	2	667194569	27.3744	<.0001*
AGEFR	1	1	306357758	25.1392	<.0001*
AGEFR^2	1	1	200601736	16.4610	<.0001*
Herd#*AGEFR	45	45	99229926.5	1.8095	0.0007*

AGEFR	Difference in Milk90 from Prev AGEFR
19	-
20	114
21	103
22	91
23	80
24	69
25	58
26	47
27	36
28	25
29	13
30	2

Elanco | Knowledge Solutions

Milk Production: 305 Milk (not mature equivalent)

Response 305M

Summary of Fit

RSquare	0.296264
RSquare Adj	0.289221
Root Mean Square Error	3887.873
Mean of Response	22645.93
Observations (or Sum Wgts)	61265

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	607	3.8599e+11	635894186	42.0689
Error	60657	9.1686e+11	15115554	Prob > F
C. Total	61264	1.3029e+12		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Herd#	46	46	2.9575e+11	425.3456	<.0001*
MonthFsh[Herd#]	508	508	4.8004e+10	6.2516	<.0001*
Calf Outcome M/F/Tw	2	2	192857236	6.3794	0.0017*
AGEFR	1	1	129193386	8.5470	0.0035*
AGEFR^2	1	1	80292141.2	5.3119	0.0212*
MastInFirst30DaysYN	1	1	4499353549	297.6638	<.0001*
MetrInFirst30DaysYN	1	1	1282676669	84.8581	<.0001*
DAInFirst30DaysYN	1	1	444355984	29.3973	<.0001*
Herd#*AGEFR	46	46	2061362555	2.9646	<.0001*

AGEFR	Difference in 305M from Prev AGEFR
19	-
20	241.2
21	219.3
22	197.3
23	175.4
24	153.5
25	131.6
26	109.6
27	87.7
28	65.8
29	43.8
30	21.9

Consider: ~150 lb more milk at $0.13/lb marginal milk = $20, BUT

- What does it cost to feed a heifer per day?
  - $1.25, $1.50, $1.75???
- Now what about multiplying that by 30 days?

Elanco | Knowledge Solutions

Milk Production: 305 Milk (not mature equivalent) (same model, but without disease variables)

Response 305M

Summary of Fit

RSquare	0.291462
RSquare Adj	0.284407
Root Mean Square Error	3901.018
Mean of Response	22645.93
Observations (or Sum Wgts)	61265

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	604	3.7973e+11	628694412	41.3127
Error	60660	9.2312e+11	15217944	Prob > F
C. Total	61264	1.3029e+12		<.0001*

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Herd#	46	46	2.9459e+11	420.8316	<.0001*
MonthFsh[Herd#]	508	508	4.7795e+10	6.1825	<.0001*
Calf Outcome M/F/Tw	2	2	213697170	7.0212	0.0009*
AGEFR	1	1	150192815	9.8695	0.0017*
AGEFR^2	1	1	981560706	6.4500	0.0111*
Herd#*AGEFR	46	46	2052201458	2.9316	<.0001*

AGEFR	Difference in 305M from Prev AGEFR
19	-
20	248.3
21	224.1
22	199.8
23	175.6
24	151.3
25	127.1
26	102.8
27	78.6
28	54.4
29	30.1
30	5.9

Consider: ~150 lb more milk at $0.13/lb marginal milk = $20, BUT

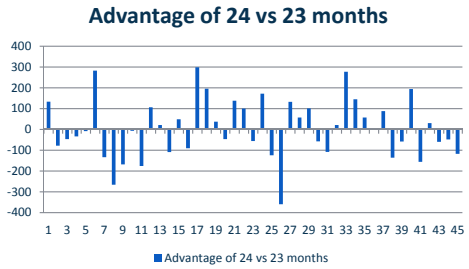
- What does it cost to feed a heifer per day?
  - $1.25, $1.50, $1.75???
- Now what about multiplying that by 30 days?

Elanco | Knowledge Solutions

USDBUNON02001

Milk production (305M)

- In this model, we still have an overall predicted advantage of 142 lb per additional month AGEFR from 22 to 26 months but there is also a herd-specific impact
- Some herds gain 300 lb more by calving at 24 vs. 23 months
- BUT, for some herds, we see less milk at 24 vs. 23 months



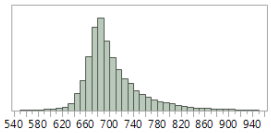
Elanco | Knowledge Solutions

USDBUNON02001

Age at First Calving Categories

Distributions

AGE at Calving_days

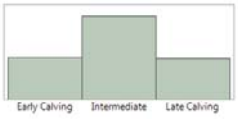


Quantiles		
100.0%	maximum	941
99.5%		878
97.5%		821
90.0%		762
75.0%	quartile	721
50.0%	median	691
25.0%	quartile	674
10.0%		660
2.5%		641
0.5%		613
0.0%	minimum	556

Summary Statistics	
Mean	702.6624
Std Dev	44.817517
Std Err Mean	0.1755163
Upper 95% Mean	703.00641
Lower 95% Mean	702.31839
N	65202

- Early calving:
  - 556 – 674 d
- Intermediate:
  - 675 – 721 d
- Late calving:
  - >721 d

AGEFR category



Frequencies

Level	Count	Prob
Early Calving	16320	0.25030
Intermediate	32711	0.50169
Late Calving	16171	0.24801
Total	65202	1.00000

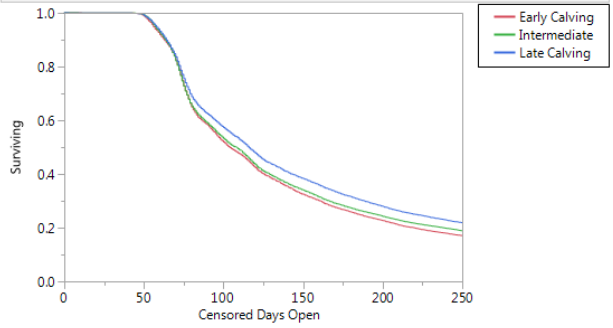
N Missing 873831
3 Levels

Elanco Knowledge Solutions

USDBUNON02001

Reproductive Performance

Survival Plot

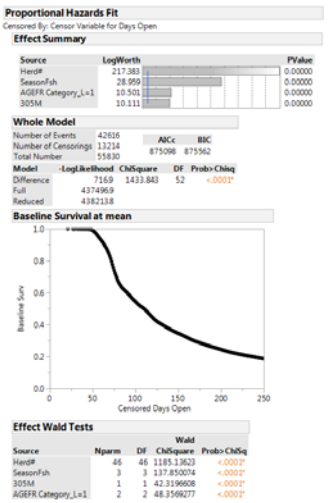


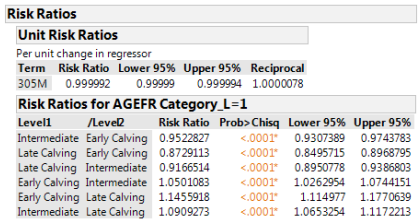
Group	% Preg by 250 DIM	Median DOPN
Early Calving	76%	104
Intermediate	74%	108
Late Calving	70%	116
Combined	73%	110

Elanco Knowledge Solutions

USDBUNON02001

Reproductive Performance Through 250 DIM



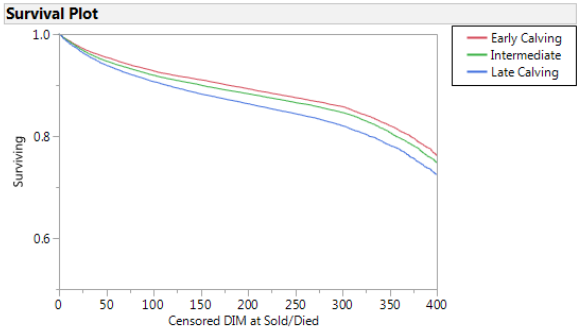


- Late calving heifers:
  - 13% lower odds of becoming pregnant by 250 vs. Early Calving
  - 8% lower odds of becoming pregnant by 250 vs. Intermediate

Elanco | Knowledge Solutions

USDBUNON02001

Culling Info



Group	% Culled by 400 DIM	Total 1st Lactation Culling Risk
Early Calving	18%	26%
Intermediate	19%	28%
Late Calving	22%	29%
Combined	19%	28%

Elanco | Knowledge Solutions

USDBUNON02001

Culling by 150 DIM

Proportional Hazards Fit

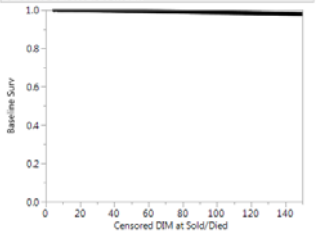
Censored By: Censor Variable for DIM at Sold/Died

Whole Model

		AICc	BIC
Number of Events	3536		
Number of Censorings	52294	67549.7	68014
Total Number	55830		

Model	-LogLikelihood	ChiSquare	DF	Prob>Chisq
Difference	4812.41	9624.826	52	<.0001*
Full	33722.79			
Reduced	38535.21			

Baseline Survival at mean



Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Herd#	46	46	2371.97933	<.0001*
SeasonFsh	3	3	31.0402118	<.0001*
305M	1	1	9016.66432	<.0001*
AGEFR Category_L=1	2	2	56.3548115	<.0001*

Risk Ratios

Unit Risk Ratios

Per unit change in regressor

Term	Risk Ratio	Lower 95%	Upper 95%	Reciprocal
305M	0.999754	0.999748	0.999759	1.0002463

Risk Ratios for AGEFR Category_L=1

Level1	/Level2	Risk Ratio	Prob>Chisq	Lower 95%	Upper 95%
Intermediate	Early Calving	1.1088201	0.0159*	1.0193967	1.2071691
Late Calving	Early Calving	1.437081	<.0001*	1.3094611	1.5777483
Late Calving	Intermediate	1.2960453	<.0001*	1.1993175	1.3998602
Early Calving	Intermediate	0.9018596	0.0159*	0.8283844	0.9809724
Early Calving	Late Calving	0.695855	<.0001*	0.6338147	0.763673
Intermediate	Late Calving	0.771578	<.0001*	0.7143571	0.8338076

- Late calving heifers:
  - 44 % higher odds of being culled by 150 vs. Early Calving
  - 30% higher odds of being culled by 150 vs. Intermediate

Elanco | Knowledge Solutions

USDBUNON02001

Culling by 400 DIM

Proportional Hazards Fit

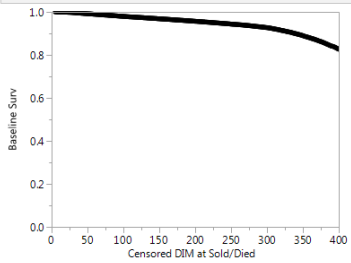
Censored By: Censor Variable for DIM at Sold/Died

Whole Model

		AICc	BIC
Number of Events	8831		
Number of Censorings	46999	174589	175053
Total Number	55830		

Model	-LogLikelihood	ChiSquare	DF	Prob>Chisq
Difference	6440.23	12880.46	52	<.0001*
Full	87242.55			
Reduced	93682.78			

Baseline Survival at mean



Effect Wald Tests

Source	Nparm	DF	Wald ChiSquare	Prob>ChiSq
Herd#	46	46	4360.85388	<.0001*
SeasonFsh	3	3	27.429634	<.0001*
305M	1	1	13158.4545	<.0001*
AGEFR Category_L=1	2	2	85.500715	<.0001*

Risk Ratios

Unit Risk Ratios

Per unit change in regressor

Term	Risk Ratio	Lower 95%	Upper 95%	Reciprocal
305M	0.999807	0.999803	0.999811	1.0001933

Risk Ratios for AGEFR Category_L=1

Level1	/Level2	Risk Ratio	Prob>Chisq	Lower 95%	Upper 95%
Intermediate	Early Calving	1.081772	0.0033*	1.0264789	1.1404226
Late Calving	Early Calving	1.3259756	<.0001*	1.2502464	1.4064361
Late Calving	Intermediate	1.2257441	<.0001*	1.1663019	1.2879196
Early Calving	Intermediate	0.9244092	0.0033*	0.876868	0.9742041
Early Calving	Late Calving	0.7541617	<.0001*	0.711017	0.7998423
Intermediate	Late Calving	0.815831	<.0001*	0.776446	0.8574109

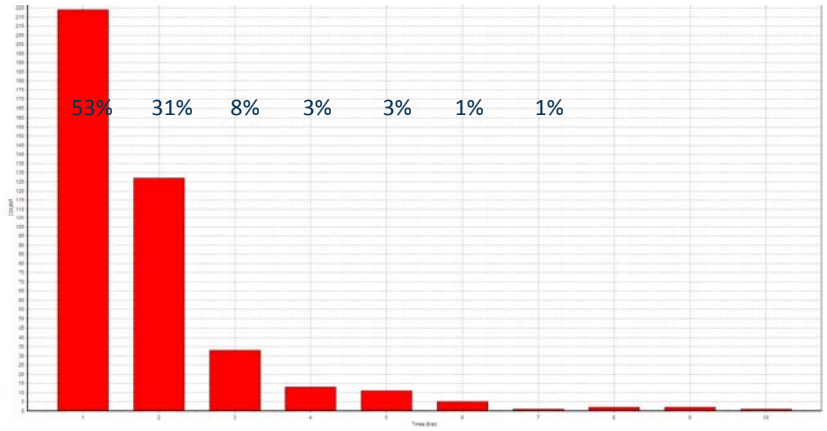
- Late calving heifers:
  - 33% higher odds of being culled by 400 vs. Early Calving
  - 23% higher odds of being culled by 400 vs. Intermediate

Elanco | Knowledge Solutions

USDBUNON02001

How Many Breeding Opportunities Do We Give Heifers?

GRAPH TBRD FOR LACT=0 AGCON=12-20



Elanco | Knowledge Solutions

USDBUNON02001

My Suggestion…

- Cull after 3-4 unsuccessful services or no more than 6 cycles of breeding opportunity
- Don't turn open heifers into a bull pen after AI
  - Often results in keeping heifers that would have been culled otherwise

Elanco | Knowledge Solutions

USDBUNON02001

21-day Pregnancy Rate

(VWP based on movement into AI pen: AIDAT)

- Fairly typical herd (in my experience):

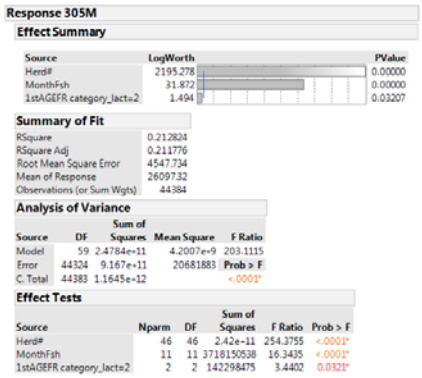
	ds AIDAT	Br Elig	Bred	Pct	Pg Elig	Preg	Pct
1	0	348	275	79	345	143	41
2	21	186	149	80	186	86	46
3	42	82	54	66	80	25	31
4	63	49	32	65	49	11	22
5	84	22	15	68	22	4	18
6	105	17	6	35	17	2	12
7	126	9	4	44	9	1	11
8	147	5	4	80	5	0	0
9	168	3	1	33	3	0	0
	Total	721	540	75	716	272	38

- If we stopped after 6th cycle…
  - Would result in culling ~ 5% or less in most herds

Elanco | Knowledge Solutions

USDBUNON02001

Second Lactation Performance



Response 305M

Effect Summary

Source	LogWorth	PValue
Herd#	2195.278	0.00000
MonthFsh	31.872	0.00000
1stAGEFR category_lact=2	1.494	0.03207

Summary of Fit

RSquare	0.212824
RSquare Adj	0.211776
Root Mean Square Error	4547.734
Mean of Response	2609.732
Observations (or Sum Wgts)	44384

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	59	2.4784e+11	4.2007e+9	203.1115
Error	44324	9.167e+11	20681883	Prob > F
C. Total	44383	1.1645e+12		<.0001*

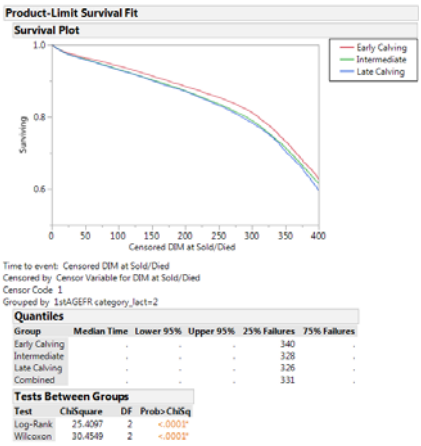
Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Herd#	46	46	2.42e+11	254.3755	<.0001*
MonthFsh	11	11	3718150538	16.3435	<.0001*
1stAGEFR category_lact=2	2	2	142298475	3.4402	0.0321*

- Impact of calving age category at First Calving on 305 Milk in 2nd Lactation:
  - Early: - 94 lb
  - Intermediate: 24
  - Late Calving: 70

Elanco | Knowledge Solutions

USDBUNON02001

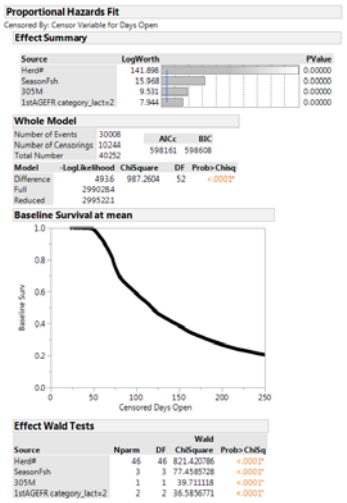


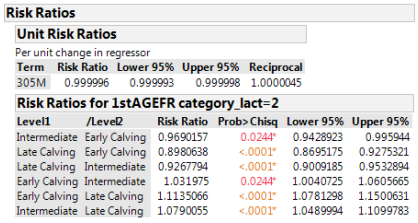
Group	Surviving through 400 DIM in 2nd Lact
Early Calving	54%
Intermediate	52%
Late Calving	50%
Combined	52%

Elanco | Knowledge Solutions

USDBUNON02001

Reproductive Performance in 2nd Lactation



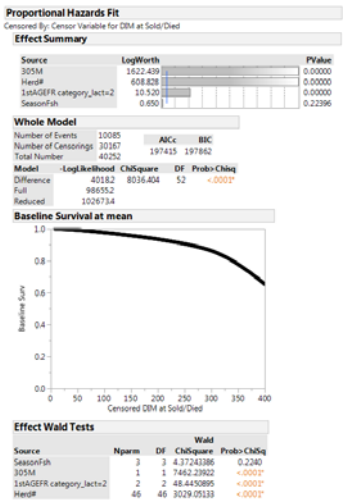


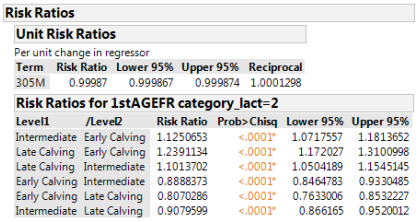
- Late calving heifers:
  - 10% lower odds of becoming pregnant by 250 vs. Early Calving
  - 7% lower odds of becoming pregnant by 250 vs. Intermediate

Elanco | Knowledge Solutions

USDBUNON02001

Culling in 2nd Lactation by 400 DIM





- Late calving heifers:
  - 24% higher odds of being culled by 400 vs. Early Calving
  - 10% higher odds of being culled by 400 vs. Intermediate

Elanco | Knowledge Solutions

USDBUNON02001

Conclusions Based on This Data Set

- Younger calving heifers produce slightly less milk but…
  - Significant herd effect
  - Extra milk not cost effective (?)
- Younger calving heifers have better reproductive performance
- Younger calving heifers have lower culling risk
- These differences carry over into 2nd lactation
  - Milk differences now smaller
  - Reproductive and culling advantages for younger heifers but impacts are smaller

Elanco | Knowledge Solutions

USDBUNON02001

Thanks For Your Attention!

Michael Overton, DVM, MPVM

(706) 248-4664

moverton@elanco.com

Elanco

Knowledge Solutions

USDBUNON02001