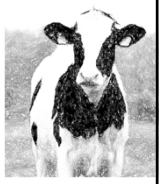
Relationship Between Actual vs. Targeted Weight at First Calving and Lactation Performance

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Take-home Points:

1. Proper growth and appropriate age at first calving help to improve milk production
2. 85% of projected mature body weight appears to be an appropriate goal for weight at first calving
3. Lightweight heifers at first calving have reduced milk production through the second lactation



2024 Georgia Dairy Conference, Savannah, Georgia

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Introduction

- Dairy replacement heifers represent a large cost but also a huge opportunity to positively influence a herd's future profitability
- Producing better quality replacements leads to higher productivity and improved profit potential
- For heifers to realize their full potential, adequate growth must occur PRIOR to calving
  - Otherwise, incremental nutrients will be more heavily allocated towards growth vs. milk production
- General guidelines suggest that heifers should weigh 82-85% of mature body weight and have achieved 95% of mature height just after calving
- However, these guidelines are typically applied using group or herd-level mean values

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Project Hypothesis:

- Heifers weighing approximately 85% of their individual projected mature body weights would achieve higher levels of milk production and experience lower removal risks as compared to lighter or heavier herd mates.

Objective:

- To estimate the differences in production, reproduction, and survival attributable to differences in actual vs. targeted body weight at first calving, where targeted weight = 85% of predicted mature body weight.

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Methods

- Animal-level data from birth through 3 lactations were obtained for all animals born during 2015 through early 2019 from the on-farm record system (DairyComp 305®) for a single, large, US Holstein herd
- Inclusion criteria:
  - Genomic test results
  - Calve at least once
  - Recorded body weight on d-1 post-calving (1 DIM)

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Methods, Continued

- Data collected included the following key variables:
  - Birth date
  - First, second and third calving dates
  - Removal date (sold or died)
  - Genomic results:
    - gBDC (genomic body size composite)
    - gMilk (genomic milk)
    - gCCR (Cow Conception Rate)
    - DWP$ (Dairy Wellness Profit Index®)
  - Weight at 1st and 3rd calving
  - Lactation-specific current (or last) test day 305-d projected milk (305M) and DIM at that test

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Methods, Continued

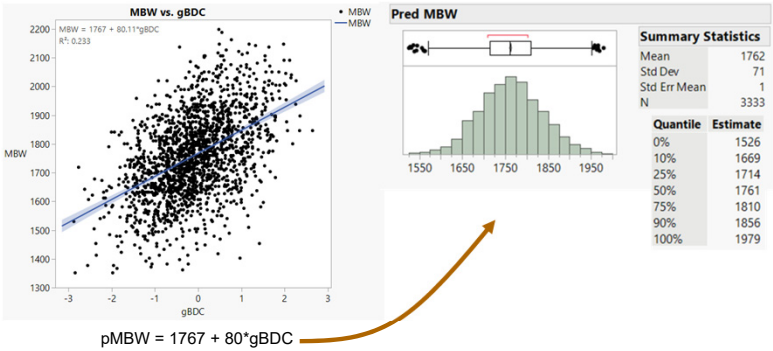
- The herd did not record body weights after the third calving
- To estimate mature body weight, adjustments were made to the 3rd lactation weights (1 DIM)
  - Cows were assumed to add an additional net gain of 2% in body weight from the start of 3rd lactation until maturity (4th lactation, 100-150 DIM)
- The estimated mature body weights were regressed against gBDC and the resulting equation was used to create a predicted mature body weight (**pMBW**) for all cows that calved at least once
- Targeted calving weight (first calving) was calculated as 0.85*pMBW
- Actual weight at first calving - Targeted calving weight = Weight 1 Difference (**L1 Wt Diff**)

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The mature body weights were regressed against gBDC

The resulting equation was used to create a predicted mature body weight (pMBW) for all cows that calved at least once



pMBW = 1767 + 80*gBDC

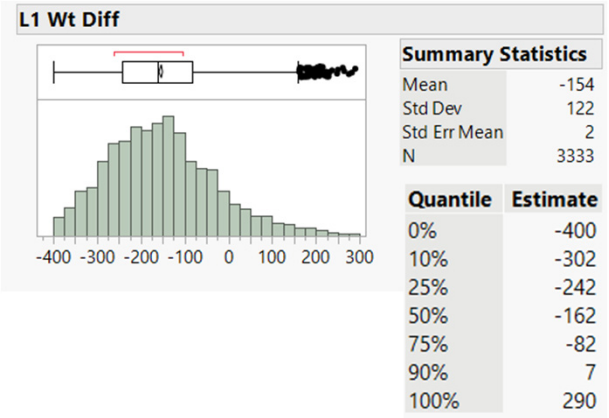
Note: the pMBW equation shown here may not fit across other herds.

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L1 Wt Diff
Actual calving weight – Targeted calving weight

(Targeted weight = 85% of predicted mature weight)



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Methods, Continued

- **L1 Wt Diff** =
  Actual weight at first calving - Targeted weight
- Three groups were created using L1 Wt Diff:
  - "Light" animals at calving:
    - (L1 Wt Diff = -400 to -76 lb, n=2549)
  - "Targeted" animals at calving:
    - (L1 Wt Diff = -75 to 75 lb, n=631)
  - "Heavy" animals:
    - (L1 Wt Diff = 76 to 290 lb, n=163)

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Statistical Methods

- Linear mixed models were used to evaluate 305M within group:
  - Lactation 1 305M:
    - Fixed effects = gMilk, DIM, DIM^2, Age at First Calving (d), and Age at First Calving^2
    - Random effects = Month and Year of calving
  - Lactation 2 305M:
    - Fixed effects = gMilk, DIM, DIM^2, Age at First Calving (d), Age at First Calving^2, Age at Second Calving (d), Age at Second Calving^2
    - Random effects = Month and Year of calving

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Results: Age at 1st Service and 1st Calving by L1 Wt Group

L1 Wt Group	Number	Age at 1st Service		Age at 1st Calving		Time to Conception
		Mean	Median	Mean	Median	Mean
Light (-400 to -76 lb)	2539	394 d (13 mo)	384 d (12.6 mo)	698 d (22.4 mo)	684 d (22.5 mo)	27 d
Targeted (-75 to 75 lb)	631	406 d (13.3 mo)	390 d (12.8 mo)	771 d (25.3 mo)	767 d (25.2 mo)	88 d
Heavy (76 to 300 lb)	163	421 d (13.8 mo)	404 d (13.3 mo)	863 d (28.4 mo)	856 d (28.1 mo)	165 d

Heifers in the Light group were inseminated earlier and became pregnant at a faster rate than either of the other groups

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Fixed Effect Model Results by L1 Wt Diff Group for 1st Lactation

Light Group

Term	Estimate	P-val
Intercept	7406	0.15
GMilk	3.2	<.01
L1 Wt Diff	**7.4**	**<.01**
DIM	33.1	<.01
DIM^2	-0.03	<.01
L1_AGEFR_d	26.0	0.06
L1_AGEFR_d^2	-0.02	0.06

Targeted Group

Term	Estimate	P-val
Intercept	19259	0.015
GMilk	3.5	<.01
L1 Wt Diff	***2.4***	***0.38***
DIM	36.9	<.01
DIM^2	-0.04	<.01
L1_AGEFR_d	-8.8	0.66
L1_AGEFR_d^2	0.01	0.65

Heavy Group

Term	Estimate	P-val
Intercept	16471	0.43
GMilk	3.2	<.01
L1 Wt Diff	***3.4***	***0.47***
DIM	72.0	<.01
DIM^2	-0.08	<.01
L1_AGEFR_d	-19.6	0.68
L1_AGEFR_d^2	0.01	0.61

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Key Takeaways for 1st Lactation Milk:

- Huge opportunity to increase milk production in 1st lactation by getting heifers closer to mature weight
  - In the light group, 7.4 lb more 305M for each additional lb closer to targeted weight
    - L1 Wt Range: -400 to -76 lb → 325 lb range → 2400 lb of milk
- Genomics works, regardless of weight group: 3.2-3.5 lb more 305M per unit increase in gMilk
  - Even larger opportunity to improve milk production through genetics
    - gMilk Range: -1667 to 2310 → 3977 range → 12,795 lb of milk
- Non-significant effects on milk production for heifers at or above targeted weight
- Curvilinear effects of Age at Fresh; in this herd, the optimal AGEFR = ~24 months

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Fixed Effect Model Results by L1 Wt Diff Group for 2nd Lactation

Light Group

Term	Estimate	P-val
Intercept	-1584	0.9
GMilk	3.4	<.01
L1 Wt Diff	**2.6**	**<.01**
L2_DIM	43.2	<.01
L2_DIM^2	-0.04	<.01
L2_AGEFR_d	16.7	0.5
L2_AGEFR_d^2	0.00	0.8
L1_AGEFR_d	26.0	0.4
L1_AGEFR_d^2	-0.02	0.3

Targeted Group

Term	Estimate	P-val
Intercept	4766	0.8
GMilk	3.5	<.01
L1 Wt Diff	***-2.6***	***0.4***
L2_DIM	56.3	<.01
L2_DIM^2	-0.05	<.01
L2_AGEFR_d	16.7	0.7
L2_AGEFR_d^2	0.00	0.8
L1_AGEFR_d	1.4	0.9
L1_AGEFR_d^2	-0.005	0.9

Heavy Group

Term	Estimate	P-val
Intercept	143134	<0.01
GMilk	3.8	<.01
L1 Wt Diff	***1.2***	***0.8***
L2_DIM	62.8	<.01
L2_DIM^2	-0.06	<.01
L2_AGEFR_d	-253.3	0.04
L2_AGEFR_d^2	0.10	0.04
L1_AGEFR_d	74.0	0.4
L1_AGEFR_d^2	-0.05	0.4

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Key Takeaways for Lactation = 2 Milk

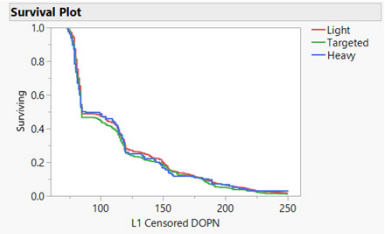
- Carryover opportunity to increase milk production by getting heifers closer to mature weight prior to 1st calving
  - In the light group, 2.6 lb more 305M in 2nd lactation for each additional lb closer to targeted weight at 1st calving
  - L1 Wt Range: -400 to -76 lb → 325 lb range → 850 lb of milk
- Genomics works, regardless of weight group: 3.4-3.8 lb more 305M per unit increase in gMilk
  - Even larger opportunity to improve milk production through genetics
    - gMilk Range: -1667 to 2310 → 3977 range → 13,751 lb of milk
- Non-significant effects on milk production for heifers at or above targeted weight

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Question: Is L1 Wt Group Associated with Pregnancy Risk Through 250 DIM in 1st Lactation?

- Based on a crude time-to-pregnancy plot and multivariate analyses, there were no differences between L1 Wt groups



- Multivariate modeling - Significant predictors:
  - Year of calving
  - genomic Cow Conception Rate (CCR)
  - NO EFFECT of L1 Wt Group on reproductive performance

Source	Nparm	DF	L-R ChiSquare	Prob>ChiSq
Year[1FDAT]	3	3	17.26	0.0006*
Month[1FDAT]	11	11	11.35	0.4146
L1_AGEFR_d	1	1	0.01	0.9334
L1_AGEFR_d^2	1	1	0.08	0.7838
CCR	1	1	37.44	<.0001*
L1 Wt Category	2	2	1.07	0.5846

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Question: Is L1 Wt Group Associated with Removal Risk (Sold or Died) in the 1st Lactation?

- Univariate results: Crude removal risks by L1 Wt Diff group for 1st lactation across full length of lactation

	Calved Again	Sold	Died
Light Group	80.1%	18.5%	1.4%
Targeted Group	82.1%	16.2%	1.7%
Heavy Group	79.8%	16.6%	3.7%

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Question: Is L1 Wt Group Associated with Removal Risk (Sold or Died) by 450 DIM in the 1st Lactation?

- Multivariate results (Cox Proportional Hazards model):
  - All factors in model were significantly ($p<0.01$) associated with risk of removal by 450 DIM:
    - Month and Year of calving
    - Age at first calving → increasing age = higher culling risk
    - DWP$ → higher DWP$ = lower culling risk
    - Across the three L1 Wt Diff groups, the Light group had a significantly higher risk of removal
      - Animals in the Light group were more likely to be culled by 450 DIM ($p<0.01$)
      - 1.7 X higher risk than Targeted
      - 1.9 X higher risk than Heavy

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Question: Is L1 Wt Group Associated with Removal Risk (Sold or Died) by 450 DIM in the 1st Lactation When Level of Milk Production is Considered?

- Same model as previously shown, but now added 305M
- Milk was very significant: Higher milk = lower culling risk
- Now, no significant effects of L1 Wt Group but a tendency for animals in the Heavy group to be at higher risk of removal
  - 1.3 X higher risk than Targeted or Light ($p=0.2$)

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Question: Is L1 Wt Group Associated with Removal Risk (Sold or Died) by 450 DIM in the 1st Lactation When Level of Milk Production is Considered?

- Same model as previously shown, but now removed Age at First Calving as an explanatory variable
- Milk was still very significant: Higher milk = lower culling risk
- All other variables still significant
- Now, the Heavy group was almost 2X more likely to be culled ($p<0.01$)

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What Does All of this Mean Regarding First Lactation Culling???

- Milk rules! More milk, regardless of group was "protective"
- The initial association between L1 Wt Group and culling was mostly explained by milk
  - The Light group produced less milk → higher culling risk
- Older heifers are more likely to leave prematurely in first lactation when level of milk production is considered
- Heavier heifers (fat?) are more likely to leave prematurely in first lactation when milk and age are considered
- Genetics are important:
  - DWP$ → higher DWP$ = lower culling risk

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Question: Is L1 Wt Group Associated with Removal Risk (Sold or Died) in the 2nd Lactation?

- Univariate results: Crude removal risks by L1 Wt Diff group across full length of the 2nd lactation:

	Calved Again	Sold	Died
Light Group	71.9%	25.1%	3.1%
Targeted Group	74.9%	23.0%	2.1%
Heavy Group	72.3%	23.1%	4.6%

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Question: Is L1 Wt Group Associated with Removal Risk (Sold or Died) by 450 DIM in the 2nd Lactation?

- Multivariate results (Cox Proportional Hazards model):
  - **No significant effect of L1 Wt Group**
  - All other factors in model were significantly ($p<0.01$) associated with risk of removal by 450 DIM except for Month of Calving:
    - Year of calving
    - Age at first calving → increasing age = higher culling risk
    - Age at second calving → increasing age = lower culling risk
    - DWP$ → higher DWP$ = lower culling risk

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Applying These Findings to the Concept of Heifer Reproduction Economics

- Commonly, heifer reproductive inefficiency costs are assigned based on the number of extra days on feed + breeding management costs
- However, as previously shown, some heifers benefit from extra days on feed while others calve too heavy and too late
- Perhaps, there is a cost of being too early or too late at first calving that must be considered at the animal level, herd level, or both

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One Way of Estimating Repro Costs

(Subset of actual results from Herd "X")

ID	Times Bred	Age (d) @ Conception	Days of Opportunity	Yardage	Breeding Cost	L1 Wt Grp	Repro Cost
17753	1	373	-85	$0	$28	Light	$28
17395	1	380	-78	$0	$28	Light	$28
17128	2	433	-25	$0	$56	Light	$56
17100	2	440	-18	$0	$56	Light	$56
17400	2	454	-4	$0	$56	Light	$56
17577	1	488	30	$90	$28	Light	$118
16795	4	544	86	$258	$92	Light	$350
17393	2	672	214	$642	$56	Light	$698
				$124	$50		**$174**

Assumptions:

- Targeted Age for Conception = 458
- Yardage/d = $3 (feed, labor, etc.)
- Semen cost (Services 1-3) = $28
- Semen cost (services 4+) = $8

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17577	1	488	30	$90	$28	Light	$118
16795	4	544	86	$258	$92	Light	$350
17393	2	672	214	$642	$56	Light	$698
				$124	$50		**$174**
17447	2	402	-56	$0	$56	Targeted	$56
17801	3	433	-25	$0	$84	Targeted	$84
17421	3	448	-10	$0	$84	Targeted	$84
18076	2	457	-1	$0	$56	Targeted	$56
16816	4	538	80	$240	$92	Targeted	$332
16731	4	567	109	$327	$92	Targeted	$419
				$95	$77		**$172**

Assumptions:

- Targeted Age for Conception = 458
- Yardage/d = $3 (feed, labor, etc.)
- Semen cost (Services 1-3) = $28
- Semen cost (services 4+) = $8

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One Way of Estimating Repro Costs

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16731	4	567	109	$327	$92	Targeted	$419
				$95	$77		**$172**
17660	4	452	-6	$0	$92	Heavy	$92
17502	4	516	58	$174	$92	Heavy	$266
17427	5	521	63	$189	$100	Heavy	$289
17287	3	615	157	$471	$84	Heavy	$555
				$209	$92		**$301**

Assumptions:

- Targeted Age for Conception = 458
- Yardage/d = $3 (feed, labor, etc.)
- Semen cost (Services 1-3) = $28
- Semen cost (services 4+) = $8

Conclusion:

- Animal conceiving later are more costly

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Cost/Value Considerations When Assessing Repro Performance in Dairy Heifers

- To more completely consider the impacts of growth and breeding performance, added a few new variables into the economic mix:
  - Extra yardage = the cost attributed to extra days in the heifer herd for animals in the "Heavy" group
  - Lost milk value = negative impacts on first lactation performance attributable to being undersized at calving ("Light" group)
  - Culling adjustment = L1 Wt Group-specific differences in first lactation removal risk attributable to Age at First Calving relative to the optimal Age at First Calving for *THIS* herd (735 d)
    - May be negative = cost savings due to calving younger
    - May be positive = added cost due to calving too old

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Proposed Approach: Consider it a "Proof of Concept" Approach

ID	Times Bred	Age (d) @ Conception	Days of Opportunity	Extra Yardage	Breeding Cost	% of pMBW	L1 Wt Grp	L1 Wt Diff (lb)	Lost Milk (lb)	Milk Value	Cull Adjustment	Est Cull Value	Total Repro Cost
17753	1	373	-85	$0	$28	69%	Light	-274	2028	$284	-7.3%	-$103	$209
17395	1	380	-78	$0	$28	70%	Light	-236	1746	$244	-6.7%	-$94	$178
17128	2	433	-25	$0	$56	73%	Light	-204	1510	$211	-2.3%	-$32	$235
17100	2	440	-18	$0	$56	69%	Light	-261	1931	$270	-1.7%	-$24	$302
17400	2	454	-4	$0	$56	75%	Light	-181	1339	$188	-0.6%	-$8	$236
17577	1	488	30	$0	$28	71%	Light	-255	1887	$264	2.3%	$32	$324
16795	4	544	86	$0	$92	80%	Light	-91	673	$94	7.0%	$98	$284
17393	2	672	214	$0	$56	67%	Light	-318	2353	$329	17.7%	$247	$633
				$0									$300
17447	2	402	-56	$0	$56	84%	Targeted	-21	0	$0.00	-3.2%	-$45	$11
17801	3	433	-25	$0	$84	85%	Targeted	-7	0	$0.00	-1.5%	-$21	$63
17421	3	448	-10	$0	$84	84%	Targeted	-23	0	$0.00	-0.6%	-$9	$75
18076	2	457	-1	$0	$56	84%	Targeted	-10	0	$0.00	-0.1%	-$1	$55
16816	4	538	80	$0	$92	83%	Targeted	-40	0	$0.00	4.5%	$63	$155
16731	4	567	109	$0	$92	82%	Targeted	-45	0	$0.00	6.1%	$86	$178
													$90
17660	4	452	-6	$0	$92	93%	Heavy	148	0	$0.00	-0.8%	-$11	$81
17502	4	516	58	$174	$92	93%	Heavy	139	0	$0.00	5.2%	$73	$339
17427	5	521	63	$189	$100	93%	Heavy	134	0	$0.00	5.7%	$79	$368
17287	3	615	157	$471	$84	91%	Heavy	109	0	$0.00	14.5%	$203	$758
				$209									$387

Indicates new info; Same info as before

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What Does This All Mean?

- Assigning extra "days on feed" plus breeding management cost is overly simplistic and fails to correctly account for complex interactions of age, size, and future productivity
- Animals calving at "Targeted Weight" were more valuable
  - Heifers fail to produce to their potential when undersized at calving, regardless of age
  - Keeping heifers on feed longer to allow more weight gain is not optimal and can lead to higher culling risk in first lactation
- Better growth and management that allows heifers to reach appropriate growth targets and size at calving, coupled with excellent reproductive management should be the focus

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Conclusion

- Non-significant effects on milk production for heifers at or above targeted weight
- Huge opportunity to increase milk production by getting lightweight heifers closer to mature weight targets prior to first calving
  - In the Light Group, 7.4 lb more 305M for each additional lb of actual calving weight (i.e., closer to targeted weight)
  - In the light group, 2.6 lb more 305M in 2nd lactation for each additional lb closer to targeted weight at 1st calving
- L1 Wt Range: -400 to -76 lb → 325 lb range →
  - 2400 lb of milk in first lactation
  - 850 lb of milk in second lactation

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Conclusion

- No effect of L1 Wt Group on reproductive performance
- Light heifers more likely to be replaced due to lower milk production
  - Old heifers and fat heifers are also more likely to be replaced early
- Genomics works, regardless of weight group: 3.2-3.5 lb more 305M per unit increase in gMilk
  - Even larger opportunity to improve milk production through genetics in this herd
    - gMilk Range: -1667 to 2310 → 3977 range → 13,100 lb of milk difference
- Curvilinear effects of Age at Fresh; in this herd, the optimal AGEFR = ~24 months

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Thank You for Your Attention!

Questions?

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zoetis

