Key Performance Indicators for the UK national dairy herd

A study of herd performance in 500 Holstein/Friesian herds for the year ending 31st August 2018

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Section 1: Key Performance Indicators for the year ending 31/08/2018

Introduction

This is the ninth annual study describing key indicators of production, fertility and health in commercial black and white dairy herds in the United Kingdom. The Key Performance Indicators (KPIs) are based on milk recording data from 500 commercial black and white herds for the 12 month period ending on 31st August 2018. Herd selection used random numbers to ensure a representative cross-section of all herds (good, bad and indifferent) that milk record with National Milk Records (NMR).

The range in performance across these herds is described for 38 parameters clearly showing the wide differences in performance, as well as huge potential for improvement, in commercial dairy herds. This includes 6 additional parameters (including mastitis rate/100 cows in milk/year) shown since the 2016 study. The principal objective throughout has been to provide farmers and technical advisers with accurate and up-to-date information on the variation in performance of commercial dairy herds.

The calculations used to generate these parameters are identical to those used by the InterHerd+ program allowing farmers and technical advisers to compare the performance of any milk recording herd directly with the 500 herd sample that is representative of the national performance. In other words, for each parameter ***is the performance of my herd typical/outlying, good/acceptable/poor when compared to the 500 herds?*** This leads on to ***"Why is a parameter where it is? Which parameters could/should we improve/prioritise and what are the likely implications?"*** If this promotes discussion between farmers and their technical advisers into the different causes and options for improvement then the study has served its primary purpose.

Following the analysis of individual parameters there is a section on trends since 2010 for a selection of the KPIs. Further sections discuss their practical use by farmers and advisers. A KPI template of 80 parameters for use in InterHerd+ is also available for users to update the KPI parameters to the target values from the 2018 study.

Parameter description

For 35 parameters described in this study (out of total of 38), the performance level of each of the 500 herds (253 herds for mastitis rate) is presented as a bar chart. The herds are displayed from "best" to "worst", in ascending or descending order depending on whether it is generally preferable to have a low value (e.g. SCC, calving interval) or a high value (e.g. dry period cure, conception rate). The "best" is always on the left side, nearest the vertical Y axis. For each parameter, a median (middle) value and inter-quartile range values (the level achieved by the middle 50% of herds) are also derived.

The **target** value proposed for each parameter (and included in the KPI template) is the level achieved by the **"best" 25%** of the herds for that parameter. In other words, **the target is set at a level currently achieved (or exceeded) by one in four dairy herds over the last year**.

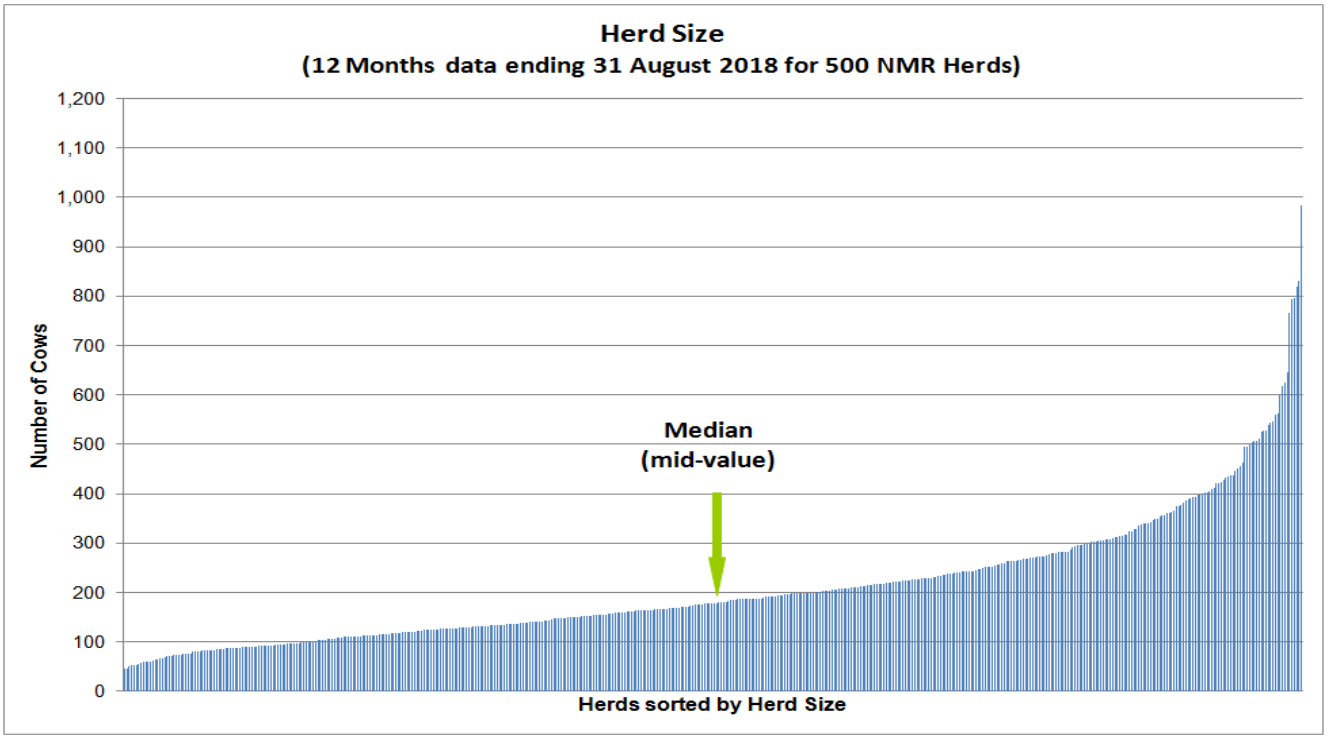
The sample of herds

The source of data is the monthly milk records obtained by National Milk Records (NMR). The 500 herds used in the study all fully milk record on a monthly assisted basis and represent approximately 10% of herds recorded by NMR. Herds were selected using random numbers to ensure a representative cross-section of the sample. The herds are all predominantly comprised of black and white breeds

(Holstein, Holstein-Friesian, Friesian) and have recorded for a minimum of two years. Where possible the same herds used in the 2017 study were maintained for the 2018 herds' sample. Herds with poor fertility data (inadequate recording of services and pregnancy diagnoses), as well as herds no longer recording, were replaced with new herds, again selected using random numbers. In total 453 herds (91%) were in both the 2017 and 2018 studies.

Herd size for the 500 herds in the 2018 study ranged from 47 to 894 cows, with a median value of 178 cows, as shown in Figure 1. In the sample 58% of herds were comprised of less than 200 cows, with 43 herds containing over 400 cows.

Figure 1. Herd size of the 500 herds in the 2018 study



The parameters

To minimize the impact of short term seasonal changes, the key performance indicator values represent the 12 month rolling averages for each parameter. In other words, they represent the performance levels achieved by each herd for the 12 months period from 1st of September 2017 to 31st of August 2018.

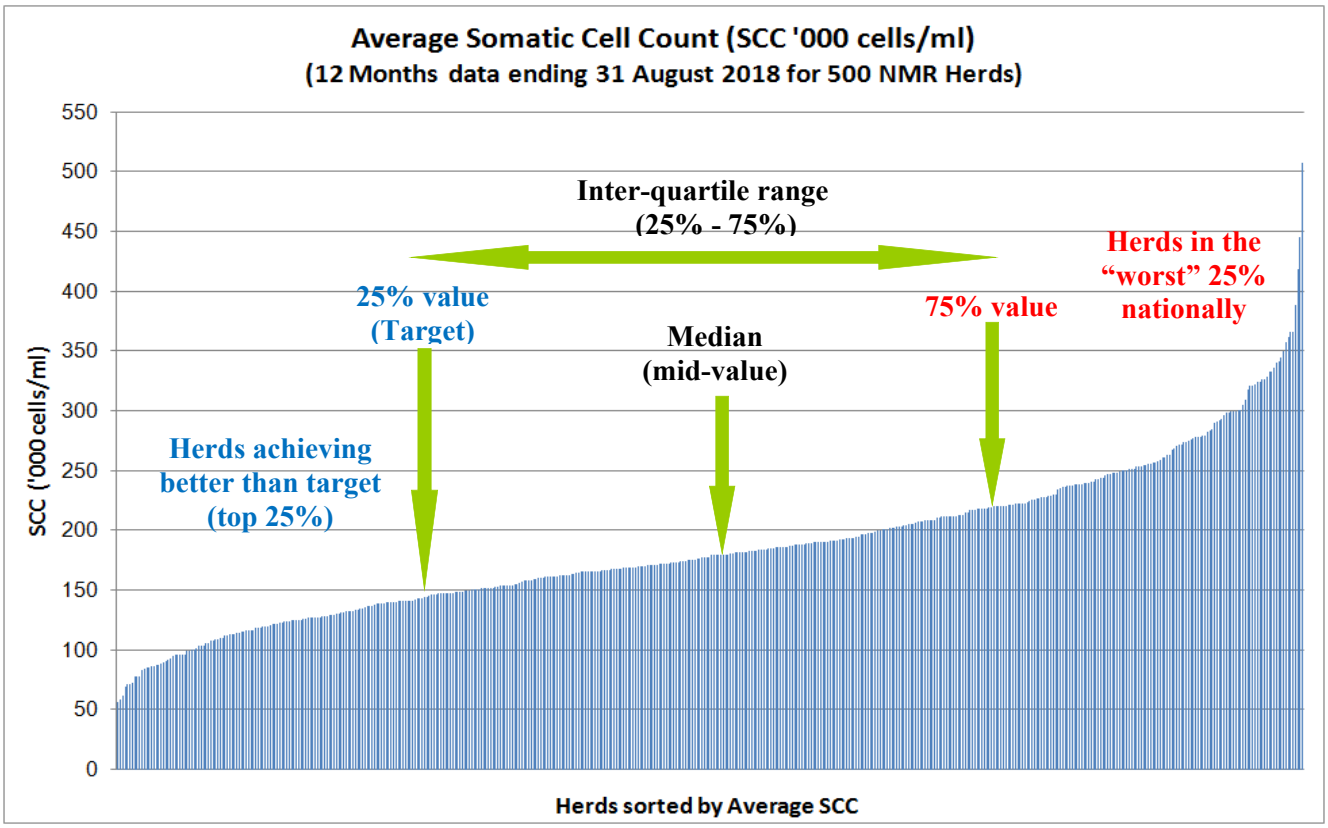
The results of the study are summarized in Tables 1(a) & 1(b). For each parameter there are 4 values:

1. The **median**: The middle value. If the performance levels of all herds are arranged in ascending order, the median is the performance of the middle herd. Half the herds do better and half do worse than the median value.
2. The **first quartile (25% value) and third quartile (75% value)** describe the lower and upper limits of performance achieved by the middle 50% of herds. 25% achieve "better" and 25% achieve "worse" than the limits for that parameter.
3. The **target** value used by InterHerd+ is the level achieved (or bettered) by 25% of the herds in the study. This value is the "**better**" of the **first quartile (25%) or third quartile (75%) values.** For parameters like somatic cell count, culling % and calving interval the target will be the 25% (lower) value, while for others (conception %, protein %, dry period cure %) it will be the 75% (higher) value.

4. The **inter-quartile range** is the difference between the performance of the best and worst 25% of herds (i.e. the difference between the **first quartile (25% value) and third quartile (75% value)**.

The origin of these values is described in Figure 2. Throughout this document the parameter value is displayed on the vertical Y axis with one bar for each of the study herds arranged along the horizontal X axis. The "best" performing herd is nearest the vertical Y axis with the worst performing herd furthest away. The parameter described in Figure 2 is the herd average SCC so the target value is at the lower end of the inter-quartile range (as a low average SCC is preferable to a high average SCC).

Figure 2. A description of the median, inter-quartile range and target values generated for each parameter



The definitions of each parameter are detailed in Appendix 2.

Changes to studies from earlier years

1. **Mastitis Key Performance indicators:** The results of the study summarized in Tables 1(a) & 1(b) include 4 parameters relating to mastitis, including the herd overall Mastitis rate (cases/100 cows in milk/year). This is the third year that mastitis related parameters have been derived from the survey herds, reflecting the significant improvement in the level of reporting of mastitis by farmers in recent years. While in 2012 less than 20% of herds reported any mastitis, this has risen to over 51% of herds in 2018. For the purpose of this study any herd that recorded over 5 cases/100 cows in milk/ year was considered to record mastitis. In total 253 of the 500 herds *(51%)* qualified and the parameters are calculated based on these 253 herds.

2. **305 day milk/protein/fat yields:** In previous reports up to that of 2015, the 305 day yield parameter was calculated from all lactations, including lactations that were shorter than 305 days. In this report, as in 2016, the lactation must be at least 305 days long for inclusion in the calculation. This report also details the 305 day yields (total yield up to and including the 305th

day of lactation) of fat and protein. As with the milk yield, these parameters are calculated from lactations that were at least 305 days in length. Note that the exclusion of lactations shorter than 305 days does not apply to the calculation of the overall lactation yield. In some circumstances, when many cows have lactation lengths below 305 days, this can result in lactation yields smaller than the 305 day yields.

3. This year the report presents new KPIs related to the sero-prevalence of Johne's disease, shown in Appendix 1. These are based on results from a sub-group of 222 herds from the 500 herds in which all cows in milk have been regularly tested (quarterly) using the milk ELISA over at least the previous 2 years.

Acknowledgements

The authors are very grateful to National Milk Records (NMR) for their assistance and cooperation with the preparation of this study.

Section 2: KPI Results for the year ending 31/08/2018

Table 1(a) Summary of Key Performance Indicators derived from analysis of 500 NMR milk recording herds for the year ending 31st August 2018 – Culling, fertility & milk parameters.

Parameter	Median (1)	1st – 3rd quartile (25% - 75%) (2)	Target (3)	Inter-quartile range (4)
A. Culling rate	27%	22% - 33%	**22%**	11%
B. Percentage culled / died 100 days after calving	6%	4% - 8%	**4%**	4%
C. Age at exit (years)	6.0	5.5 - 6.7	**6.7**	1.2
D. Age at exit by lactations	3.6	3.2 - 4.1	**4.1**	0.9
E. Percentage Served by day 80	57%	44% - 68%	**68%**	24%
F. Percentage conceived 100 days after calving	34%	25% - 41%	**41%**	16%
G. Calving to 1st service interval (days)	81	71 - 100	**71**	29
H. Calving interval (days)	400	388 - 418	**388**	30
I. Age at 1st calving (years)	2.3	2.1 - 2.5	**2.1**	0.4
J. Conception rate	35%	29% - 42%	**42%**	13%
K. %Service intervals at 18-24 days (Heat detection)	35%	28% - 42%	**42%**	14%
L. Percentage service intervals >50 days	23%	16% - 31%	**16%**	15%
M. %Cows eligible for service served (Submission rate)	37%	26% - 49%	**49%**	23%
N. %Eligible for service that conceived (Pregnancy rate)	13%	9% - 17%	**17%**	8%
O. Lifetime milk / cow / day (kg)	12.5	10.5 - 14.7	**14.7**	4.2
P. Milk / cow / year (kg)	8,446	7,315 - 9,487	**9,487**	2,172
Q. Average protein%	3.28%	3.21% - 3.35%	**3.35%**	0.14%
R. Average fat%	4.02%	3.86% - 4.18%	**4.18%**	0.32%
S. 305-day milk yield (kg)	8,967	7,914 - 9,925	**9,925**	2,011
T. 305-day protein yield (kg)	290	260 - 321	**321**	61
U. 305-day fat yield (kg)	356	317 - 393	**393**	76

(1) The median is the middle value (so 250 herds were better and 250 were worse than this value).

(2) The **first quartile (25% value) and third quartile (75% value)** describe the lower and upper limits of performance achieved by the middle 50% of herds. 25%, or one in four, herds achieve "better" and 25% "worse" than the limits for that parameter.

(3) The **Target** is set at the level achieved by the **"best" 25% of herds**. **One in four of the 500 herds in the sample achieved this level or better**.

(4) The inter-quartile range encompasses half the study herds. It is the difference in performance between a herd achieving the target (**best 25% value)** and a herd at the **worst quartile (75% value)**.

Table 1(b) Summary of Key Performance Indicators derived from analysis of 500 NMR milk recording herds for the year ending 31st August 2018 – Somatic Cell Count (SCC) and mastitis parameters.

Parameter	Median (1)	1st – 3rd quartile (25% - 75%) (2)	Target (3)	Inter-quartile range (4)
V. Herd SCC ('000 cells/ml)	178	142 - 221	**142**	79
W. % milk samples with **High** SCC (*)	18%	14% - 23%	**14%**	9%
X. % milk samples with SCC >=500,000 cells/ml	7%	5% - 9%	**5%**	4%
Y. % cows with **High** SCC at 1st recording in lactation (*)	17%	13% - 22%	**13%**	9%
Z. % **Chronic** milk samples (**)	10%	7% - 13%	**7%**	6%
ZA. Dry period cure (High:Low) (***)	76%	68% - 83%	**83%**	15%
ZB. Dry period protection (Low:Low) (***)	85%	79% - 89%	**89%**	10%
ZC. % Low at last recording of previous lactation (*)	72%	63% - 81%	**81%**	18%
ZD. % samples New SCC category (**)	7%	5% - 8%	**5%**	3%
ZE. % cows dried-off with no High SCC samples in the lactation (*)	44%	36% - 53%	**53%**	17%
ZF. Threshold Index new high / new low (****)	1.27	1.16 - 1.41	**1.16**	0.25
ZG. % of cows with New/First/Repeat sample that are Low SCC at next recording (**)	55%	50% - 60%	**60%**	10%
ZH. % of cows with Chronic sample that are low SCC at next recording (**)	20%	16% - 25%	**25%**	9%
ZI. Percentage drying off with no mastitis cases+	80%	72% - 87%	**87%**	15%
ZG. Mastitis rate (cases/100 cows in milk/year)+	31	19 - 49	**19**	30
ZK. Cows with Index mastitis case by Day 30+	5%	3% - 8%	**3%**	5%
ZL. Index mastitis rate after Day 30+	20%	12% - 31%	**12%**	19%

(*) **HIGH** SCC is a milk sample with >=200,000 cells/ml milk;
LOW SCC is a milk sample with below 200,000 cells/ml milk

(**) **CHRONIC / NEW / FIRST** and **REPEAT** are the Herd Companion categories describing high SCC cows. See Appendix 2 for definitions.

(***) **Dry period protection (High:Low):** The percentage of cows finishing a lactation with a HIGH SCC sample that starts the new lactation with a LOW SCC sample;
Dry Period Cure (Low:Low): The percentage of cows finishing a lactation with a LOW SCC sample that starts the new lactation with a LOW SCC sample.

(****) **Threshold Index:** The total cows changing from Low to High SCC divided by the total cows changing from High to Low SCC at consecutive milk recordings.

(1) The median is the middle value (so 250 herds were better and 250 were worse than this value).

(2) The **first quartile (25% value) and third quartile (75% value)** describe the lower and upper limits of performance achieved by the middle 50% of herds. 25%, or one in four, herds achieve "better" and 25% "worse" than the limits for that parameter.

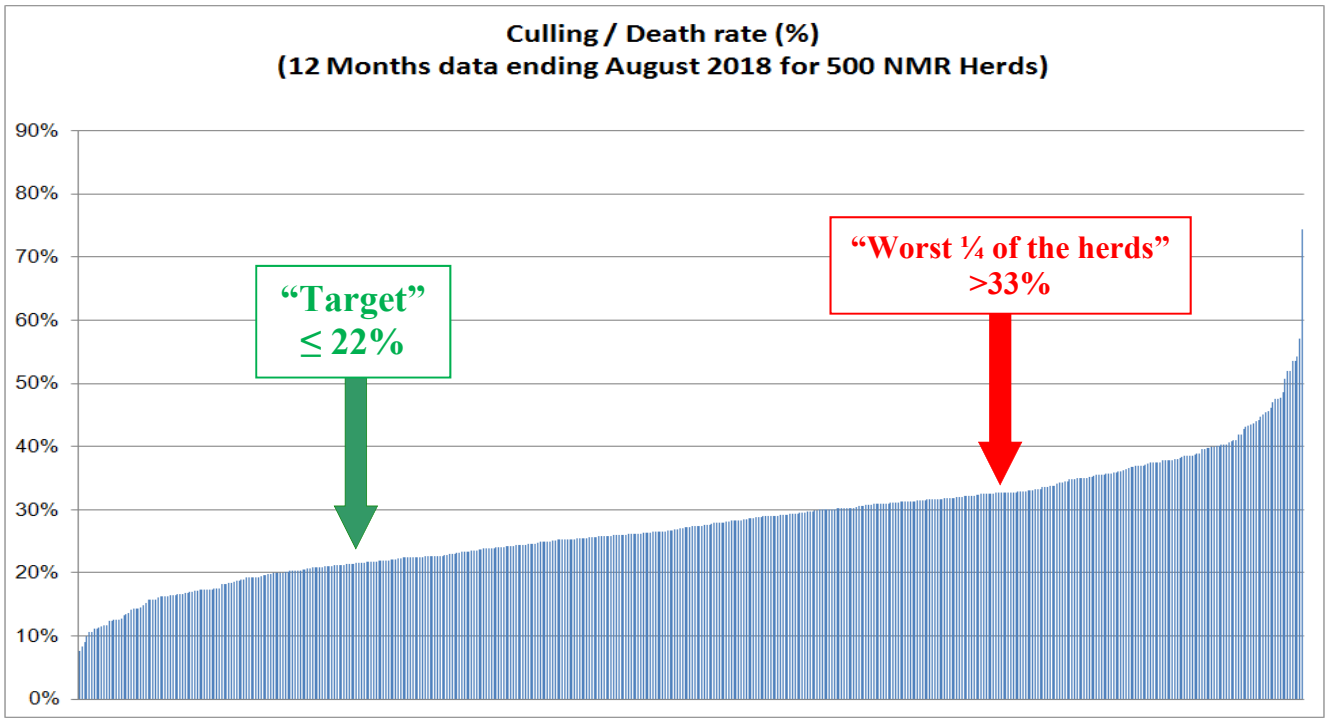
(3) The **Target** is set at the level achieved by the **"best" 25% of herds**. **One in four of the 500 herds in the sample achieved this level or better**.

(4) The inter-quartile range encompasses half the study herds. It is the difference in performance between a herd achieving the target (**best 25% value)** and a herd at the **worst quartile (75% value)**.

\+ **The mastitis parameters are derived from a group of 253 herds (within the 500 herds in the study) where mastitis rate >5 cases per 100 cows in milk / year.**

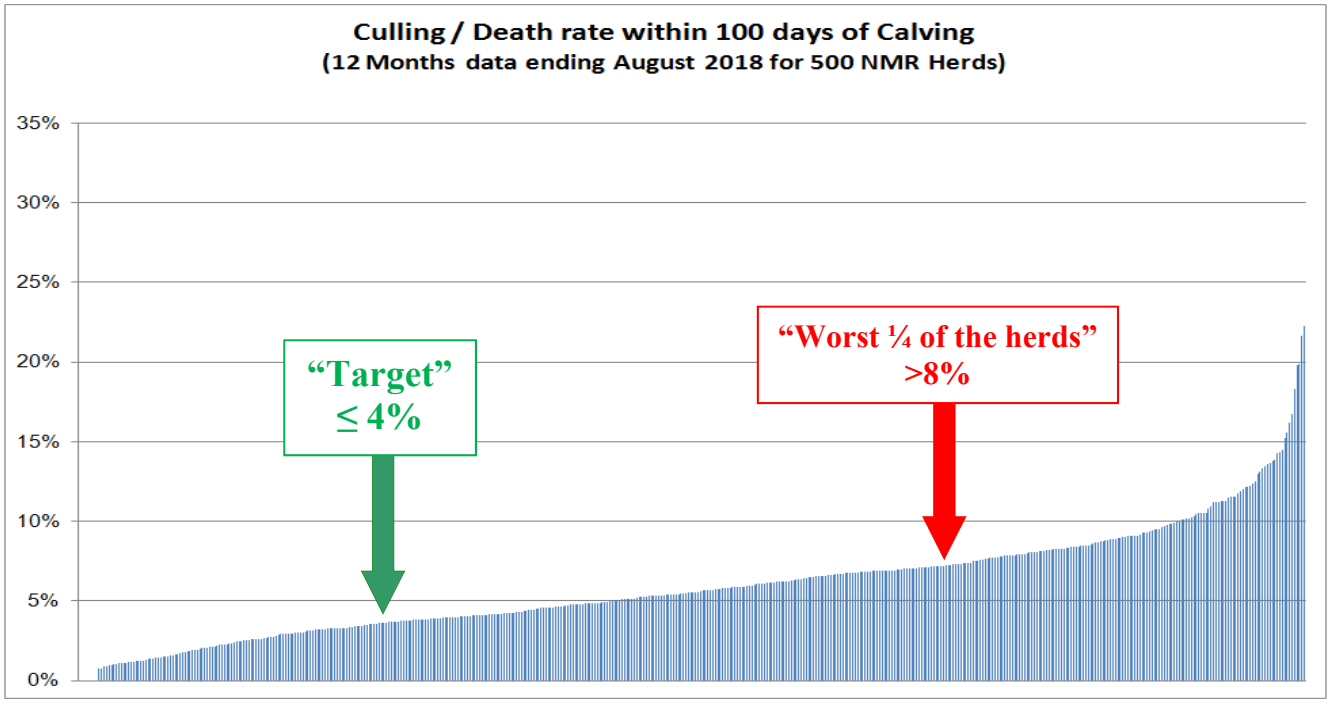
A. Culling/death rate: The % of cows that left the herd (culled/sold/died) in the last 12 months.

Target (top ¼ of herds' level): 22%
Median: 27%
75% level: 33%
Inter-quartile range: 11%



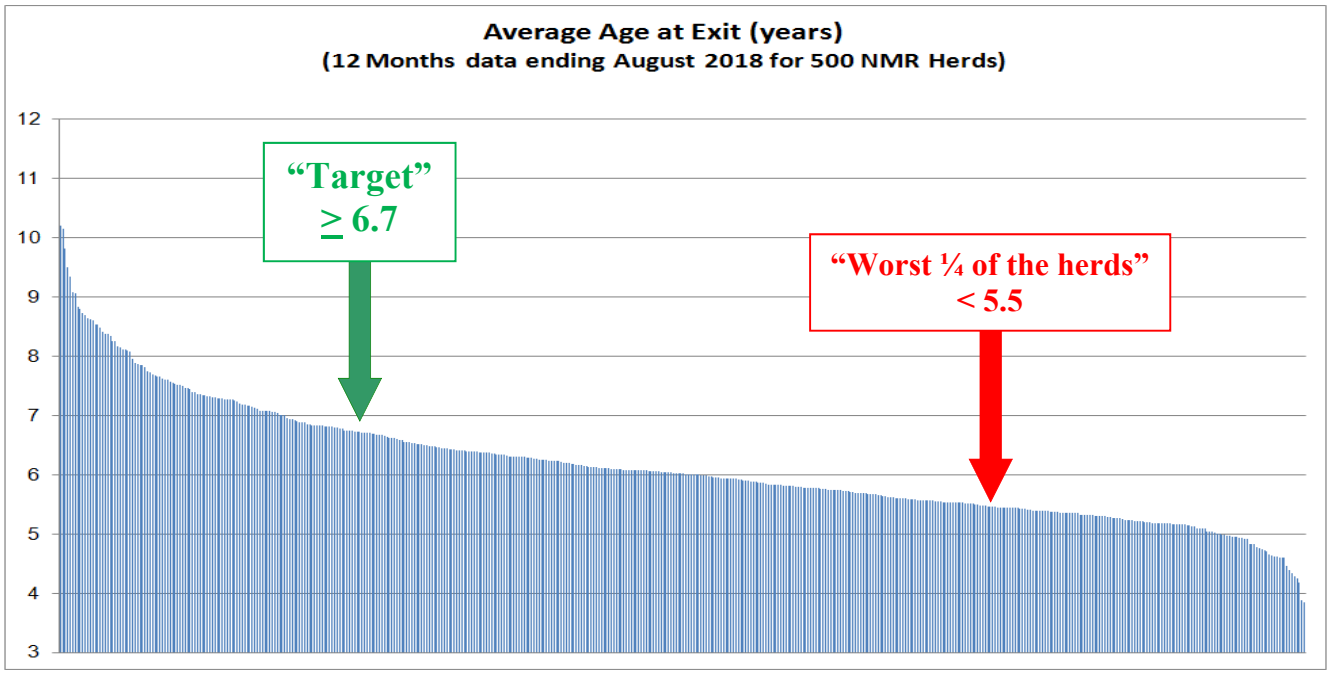
B. Percentage of cows/heifers calving during the last 12 months that were culled / died during the first 100 days after calving. A possible indicator of "involuntary culling".

Target (top ¼ of herds' level): 4%
Median: 6%
75% level: 8%
Inter-quartile range: 4%



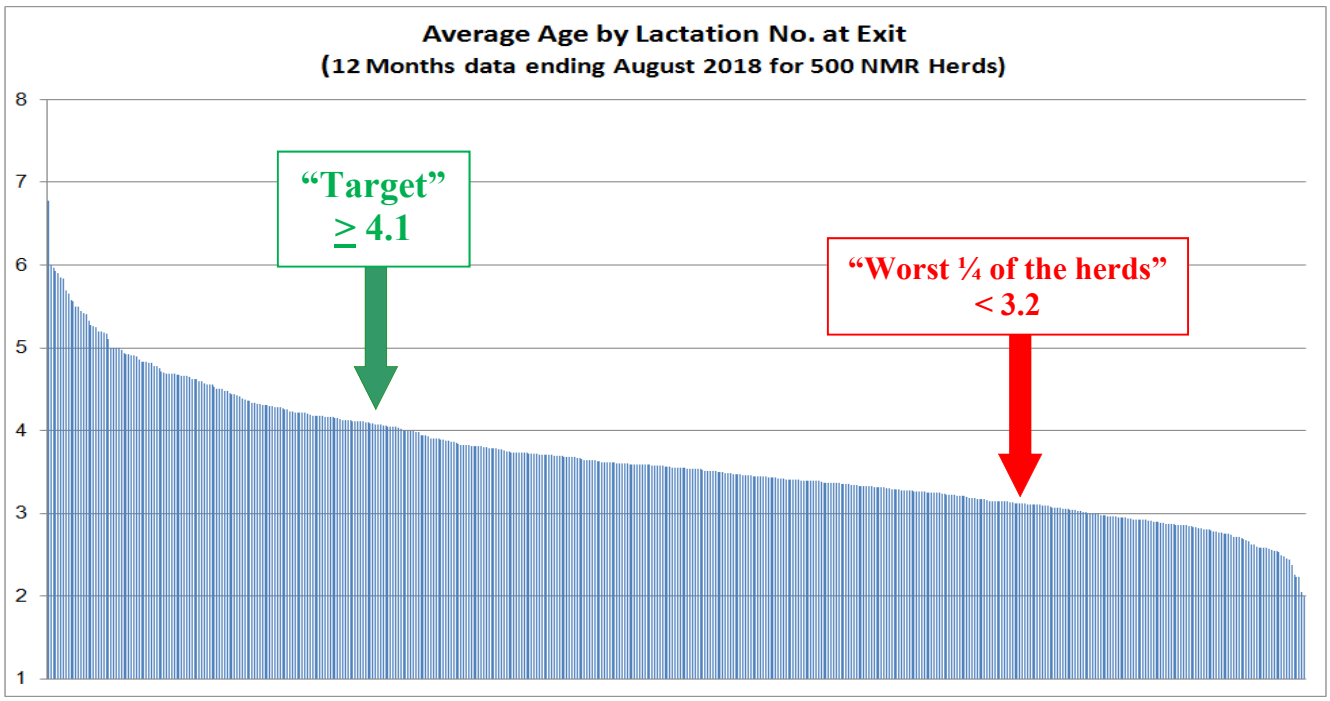
C. Average Age (in years) at exit: The average age of cows leaving the herd in the last 12 months at the time of exit. A potential measure of longevity.

Target (top ¼ of herds' level):	**6.7**
Median:	6.0
75% level:	5.5
Inter-quartile range:	1.2



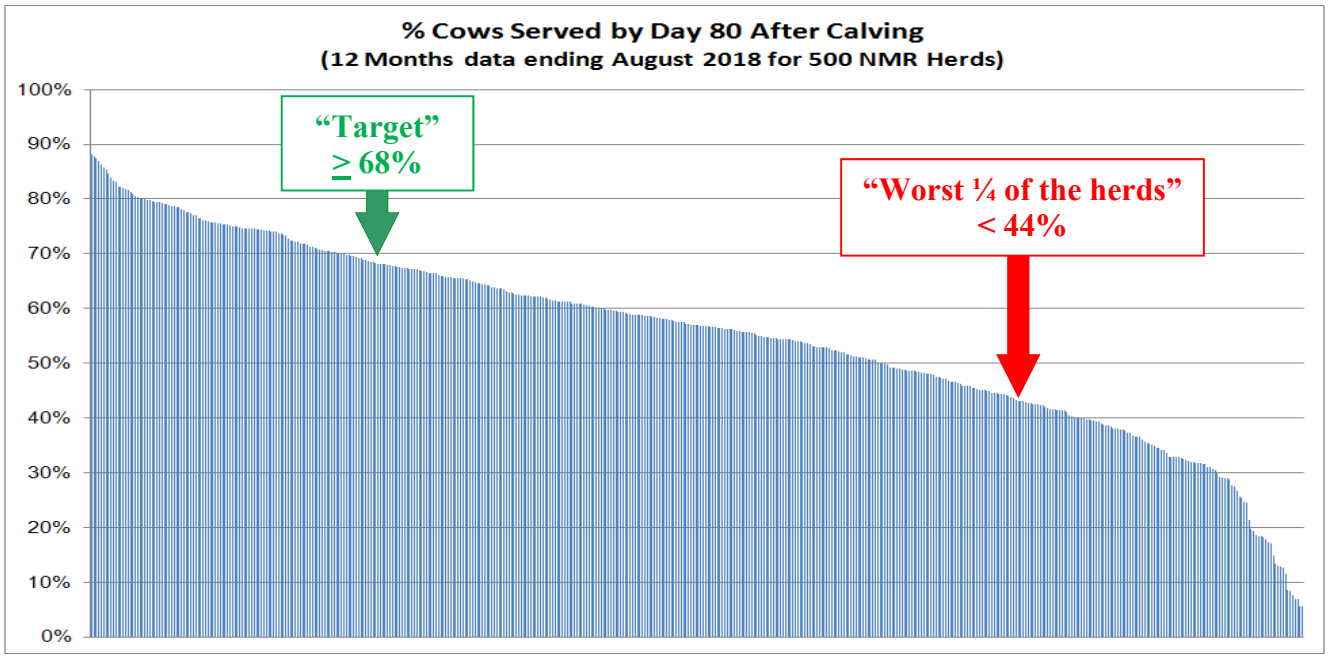
D. Average Age at exit by lactations: The average lactation number of cows leaving the herd in the last 12 months. A potential measure of longevity.

Target (top ¼ of herds' level):	**4.1**
Median:	3.6
75% level:	3.2
Inter-quartile range:	0.9



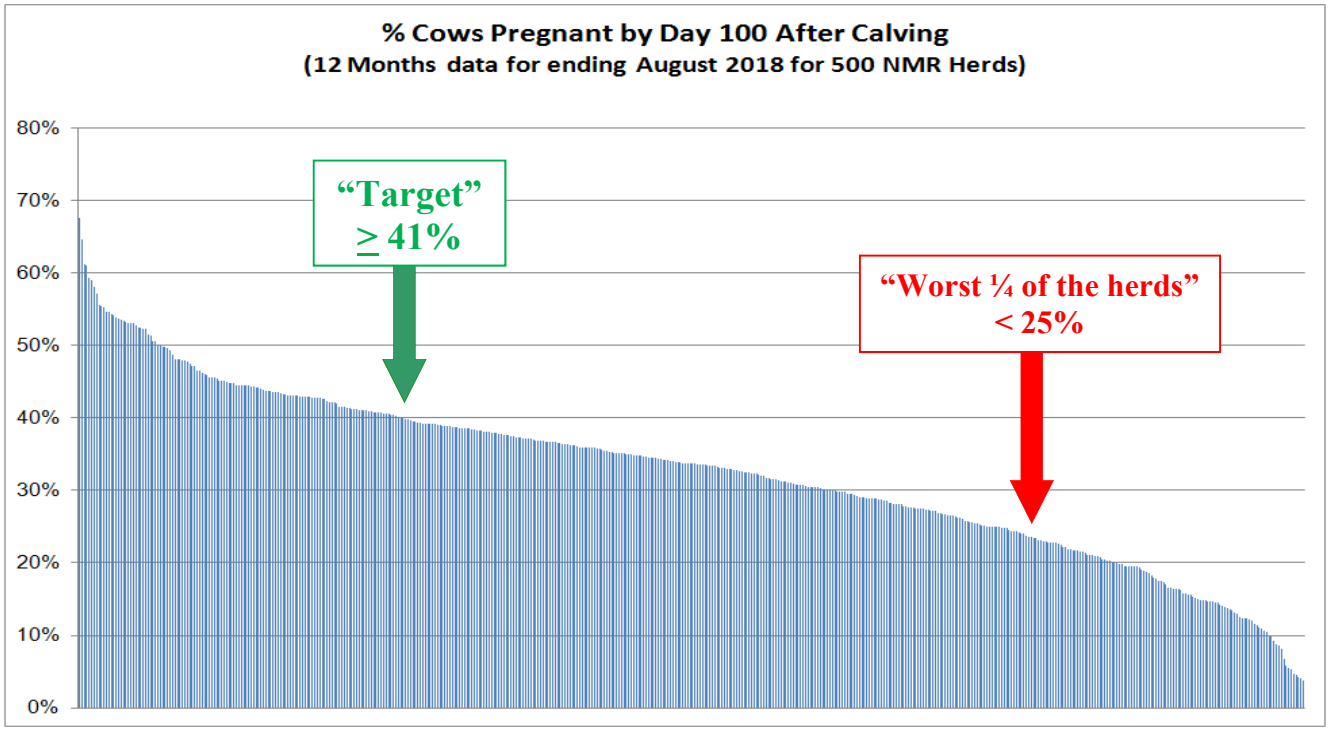
E. Served by day 80: The percentage of calving cows served at least once within 80 days of calving.

Target (top ¼ of herds' level):	**68%**
Median:	57%
75% level:	44%
Inter-quartile range:	24%



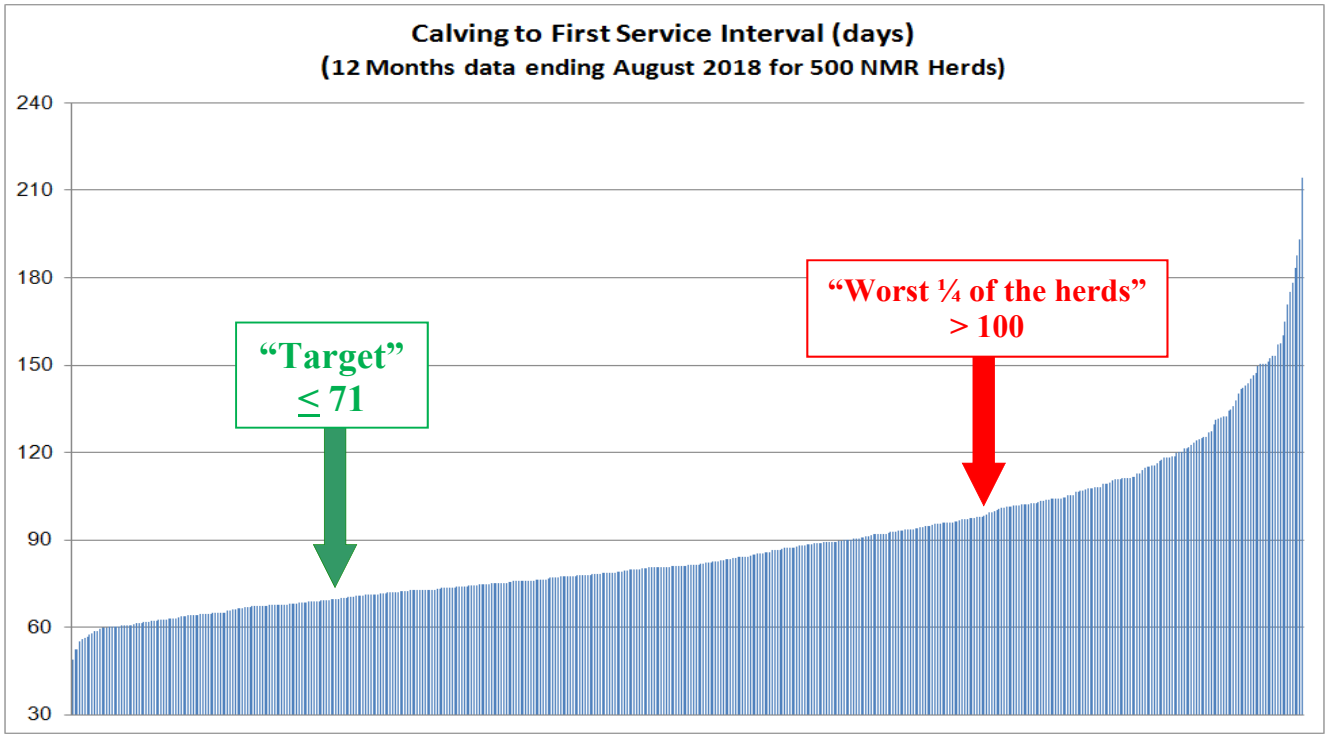
F. Percentage conceived 100 days after calving: The percentage of calving cows that had conceived within 100 days of calving.

Target (top ¼ of herds' level):	**41%**
Median:	34%
75% level:	25%
Inter-quartile range:	16%



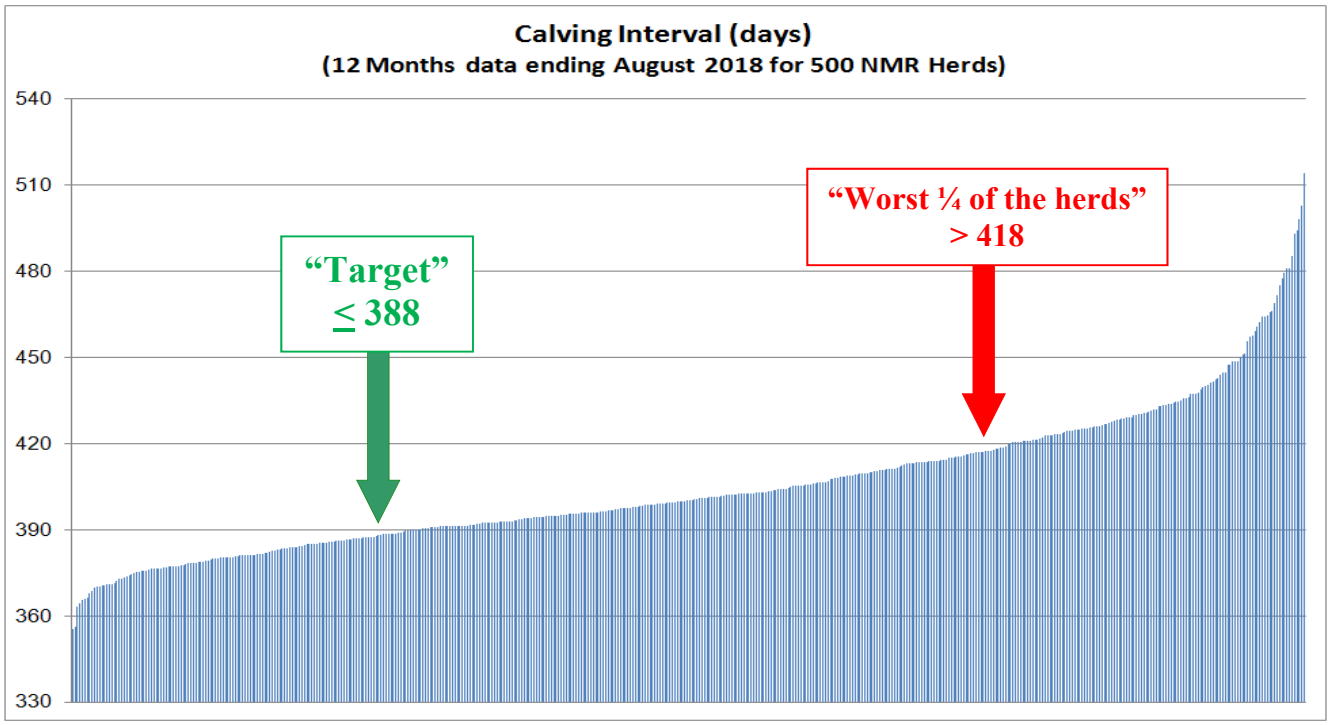
G. Calving to 1st service interval: The average number of days between calving and 1st service.

Target (top ¼ of herds' level):	**71**
Median:	81
75% level:	100
Inter-quartile range:	29



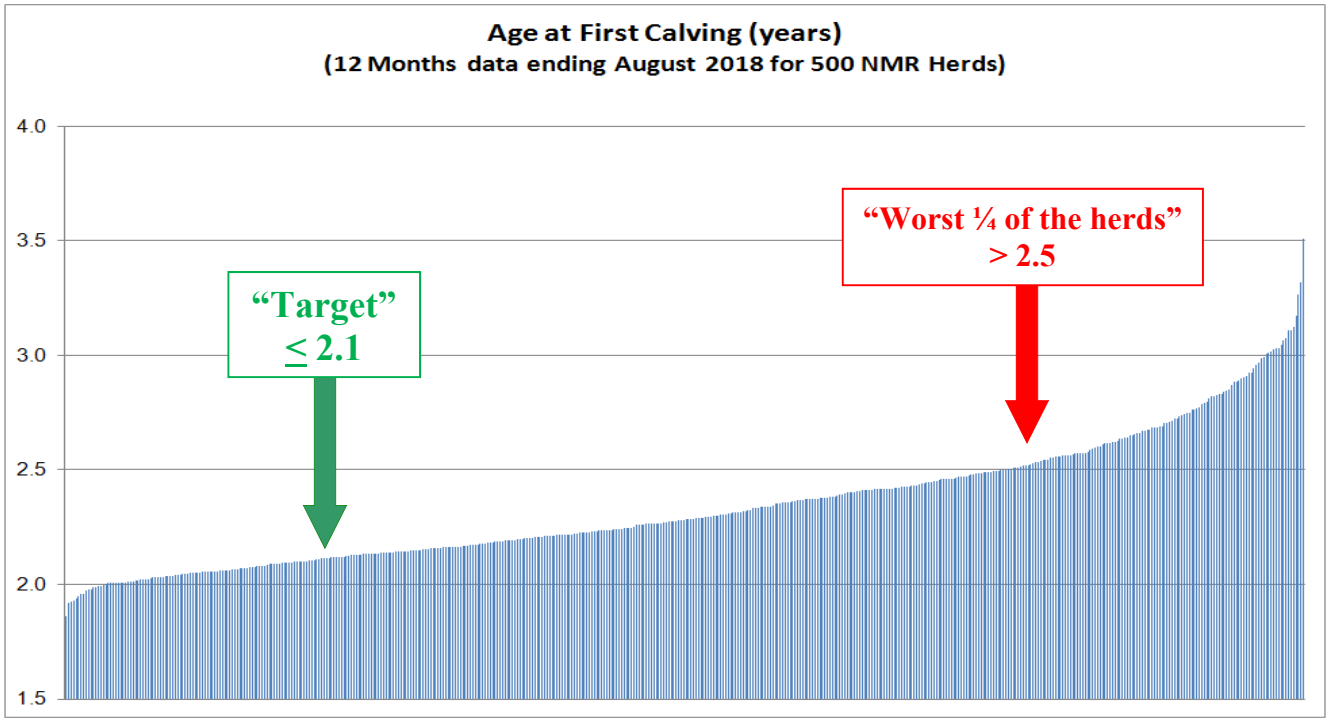
H. Calving interval: The average interval between consecutive calvings (in days).

Target (top ¼ of herds' level):	**388**
Median:	400
75% level:	418
Inter-quartile range:	30



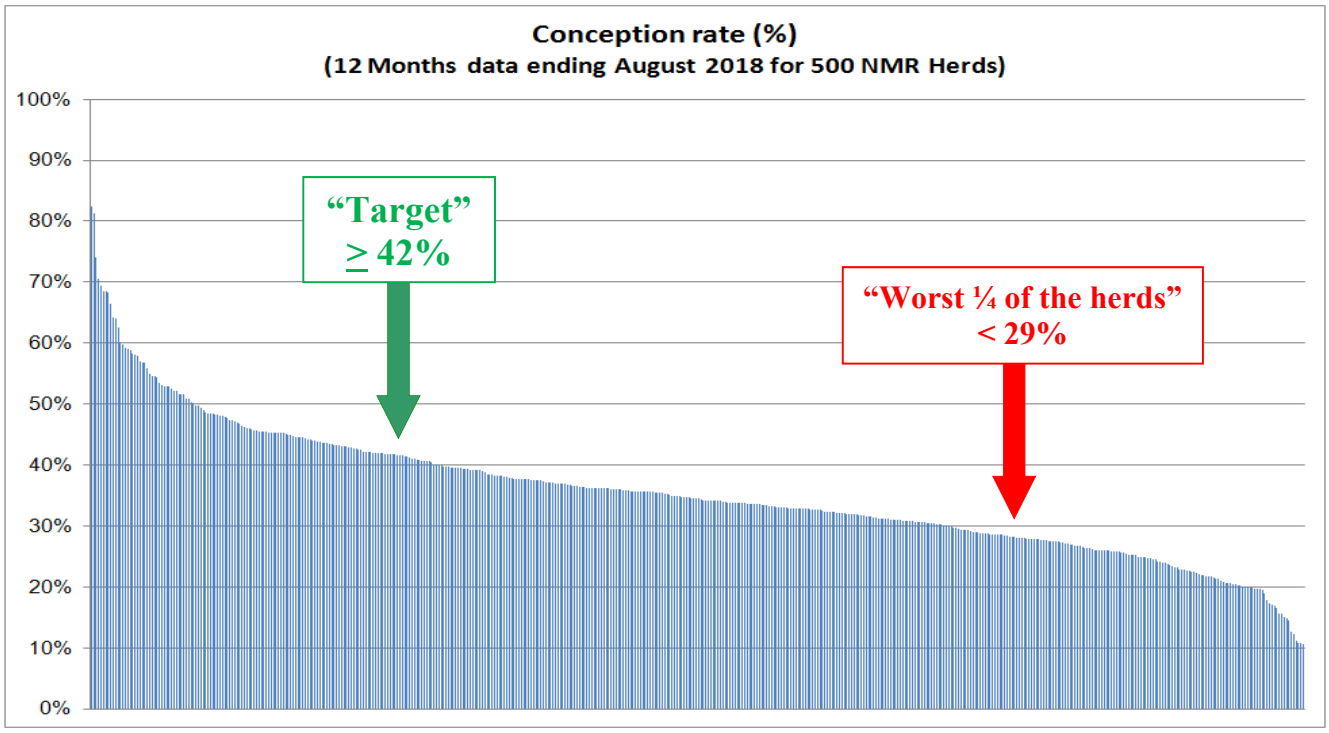
I. Age at 1st calving: The average age (in years) of heifers calving down over the last year.

Target (top ¼ of herds' level):	**2.1**
Median:	2.3
75% level:	2.5
Inter-quartile range:	0.4



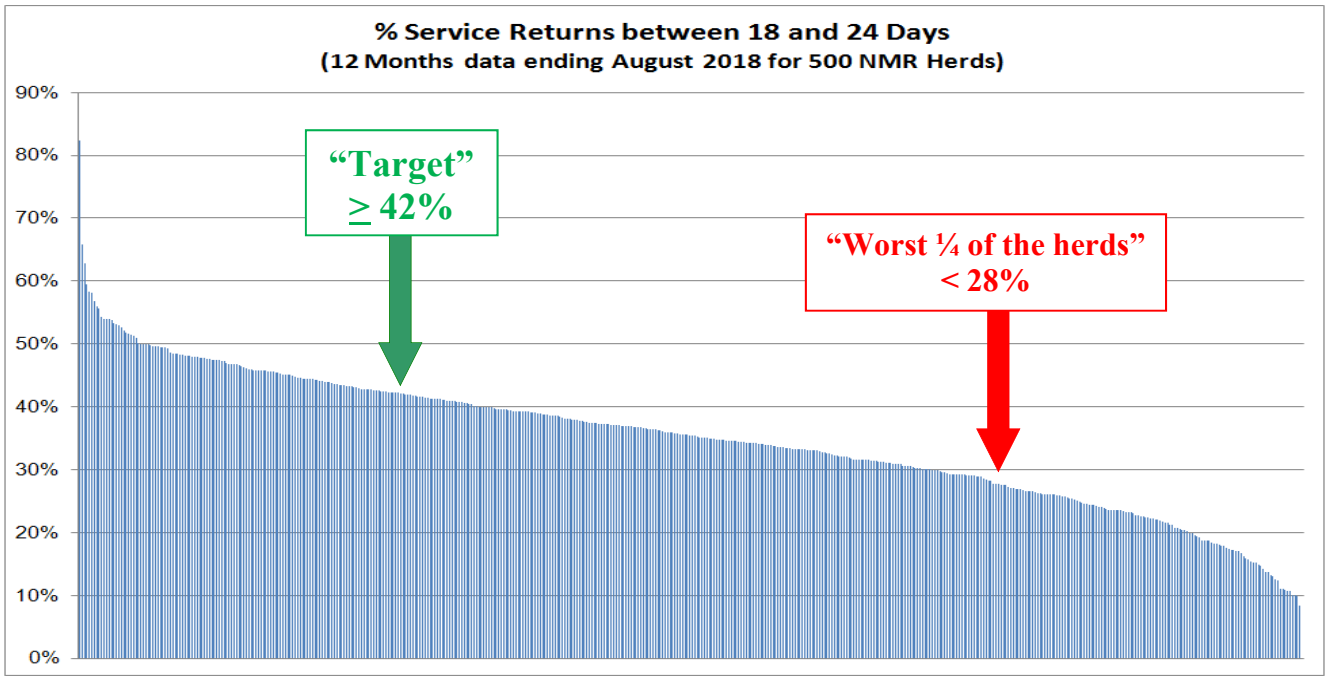
J. Conception rate: The average conception rate for all services in the last 12 months.

Target (top ¼ of herds' level):	**42%**
Median:	35%
75% level:	29%
Inter-quartile range:	13%



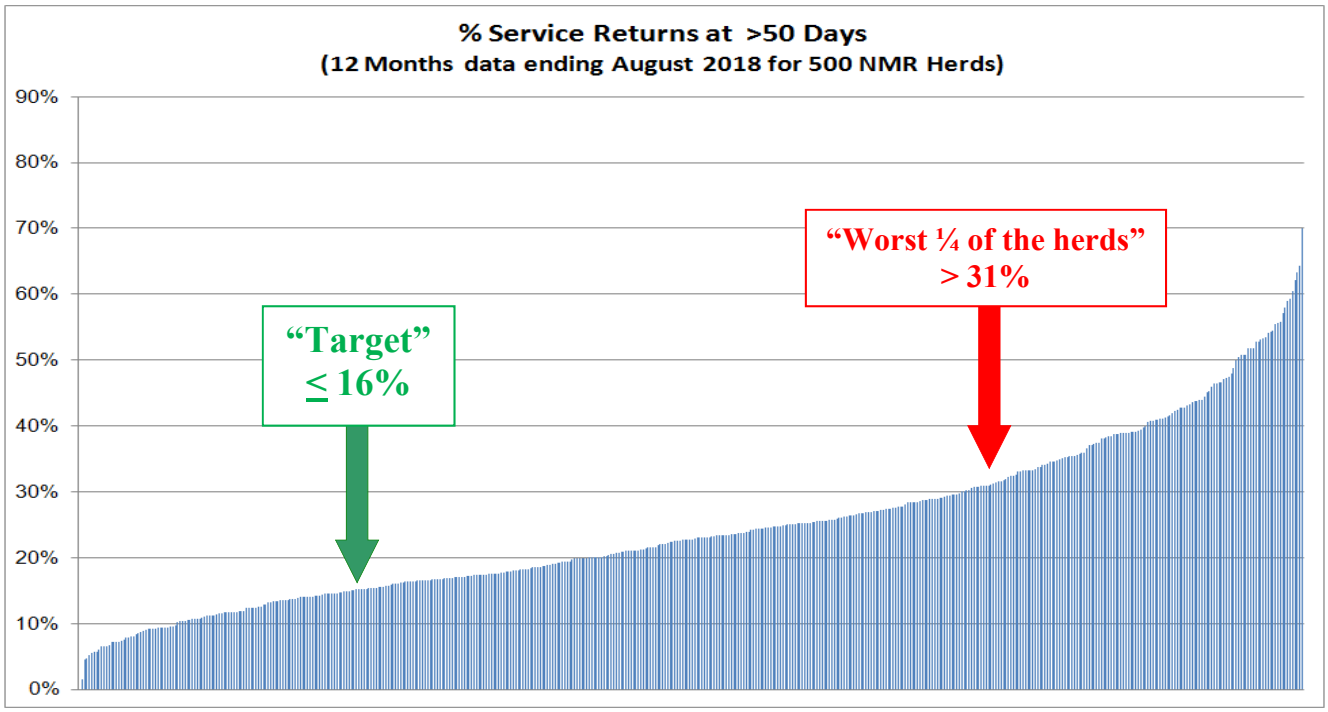
K. Percentage service intervals at 18-24 days (Heat detection): The % of all repeat services occurring 18-24 days (one oestrus cycle) after the previous service.

Target (top ¼ of herds' level):	**42%**
Median:	35%
75% level:	28%
Inter-quartile range:	14%



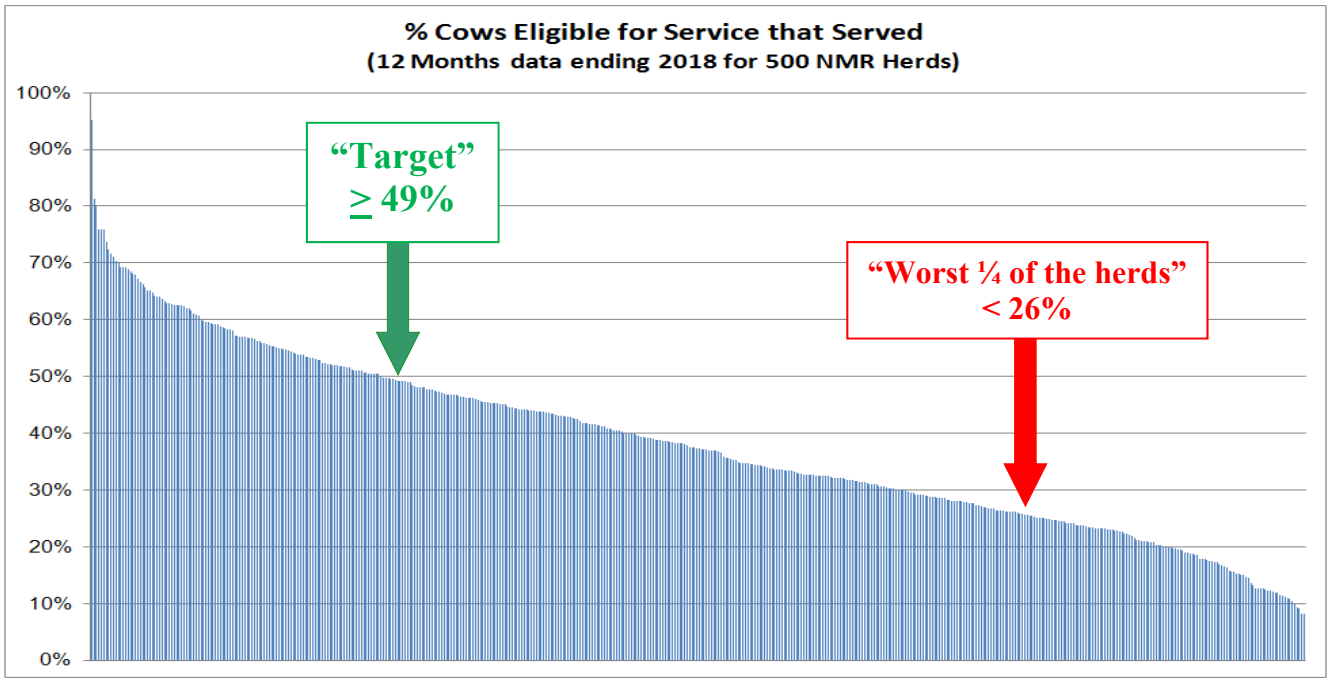
L. Percentage service intervals >50 days: The % of all repeat services with an interval of over 50 days since the previous service. A potential indicator of poor heat detection.

Target (top ¼ of herds' level):	**16%**
Median:	23%
75% level:	31%
Inter-quartile range:	15%



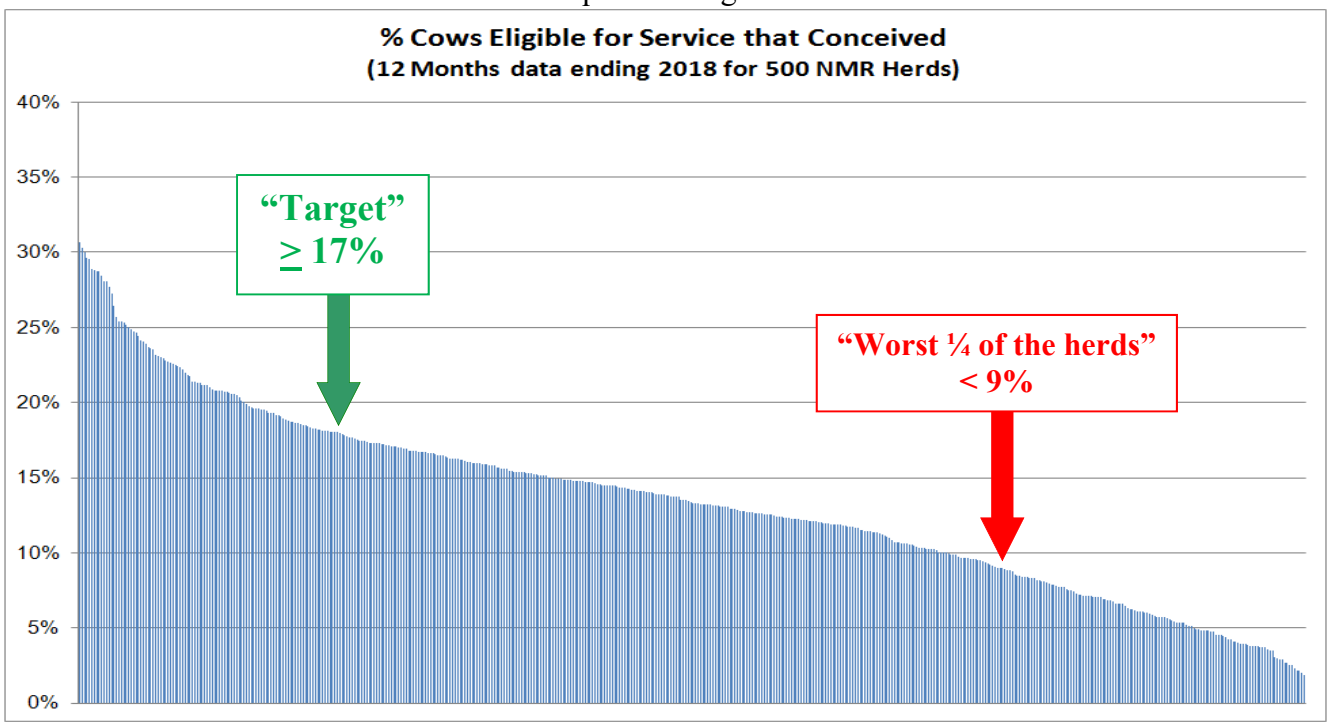
M. Percentage of cows eligible for service (>42 days calved, not barren, not pregnant) that were served per 21 day oestrus period (Submission rate).

Target (top ¼ of herds' level):	**49%**
Median:	37%
75% level:	26%
Inter-quartile range:	23%



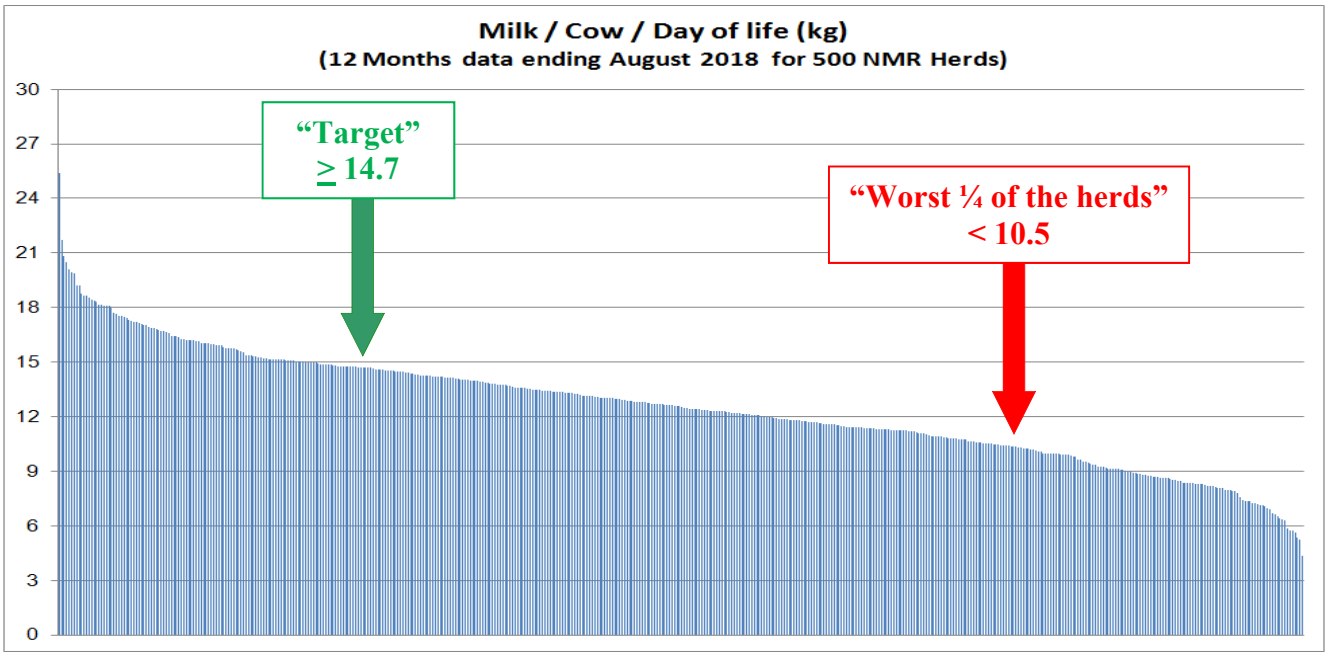
N. Percentage eligible for service (>42 days calved, not barren, not pregnant) that conceived per 21 day oestrus period (Pregnancy rate).

Target (top ¼ of herds' level):	**17%**
Median:	13%
75% level:	9%
Inter-quartile range:	8%



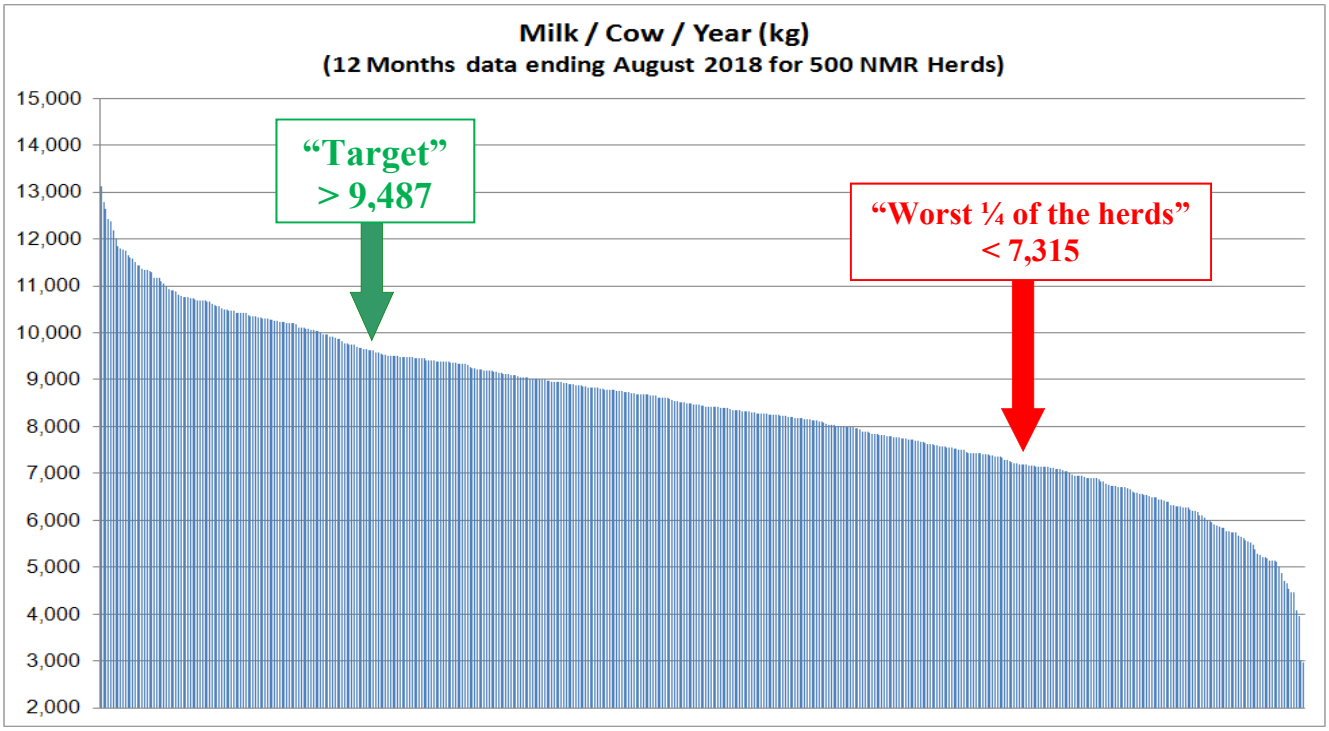
O. Lifetime milk / cow / day (kg): Equates to the average daily milk yield of cows across their whole lifetime (including unproductive periods: time as a heifer, dry period).

Target (top ¼ of herds' level):	**14.7**
Median:	12.5
75% level:	10.5
Inter-quartile range:	4.2



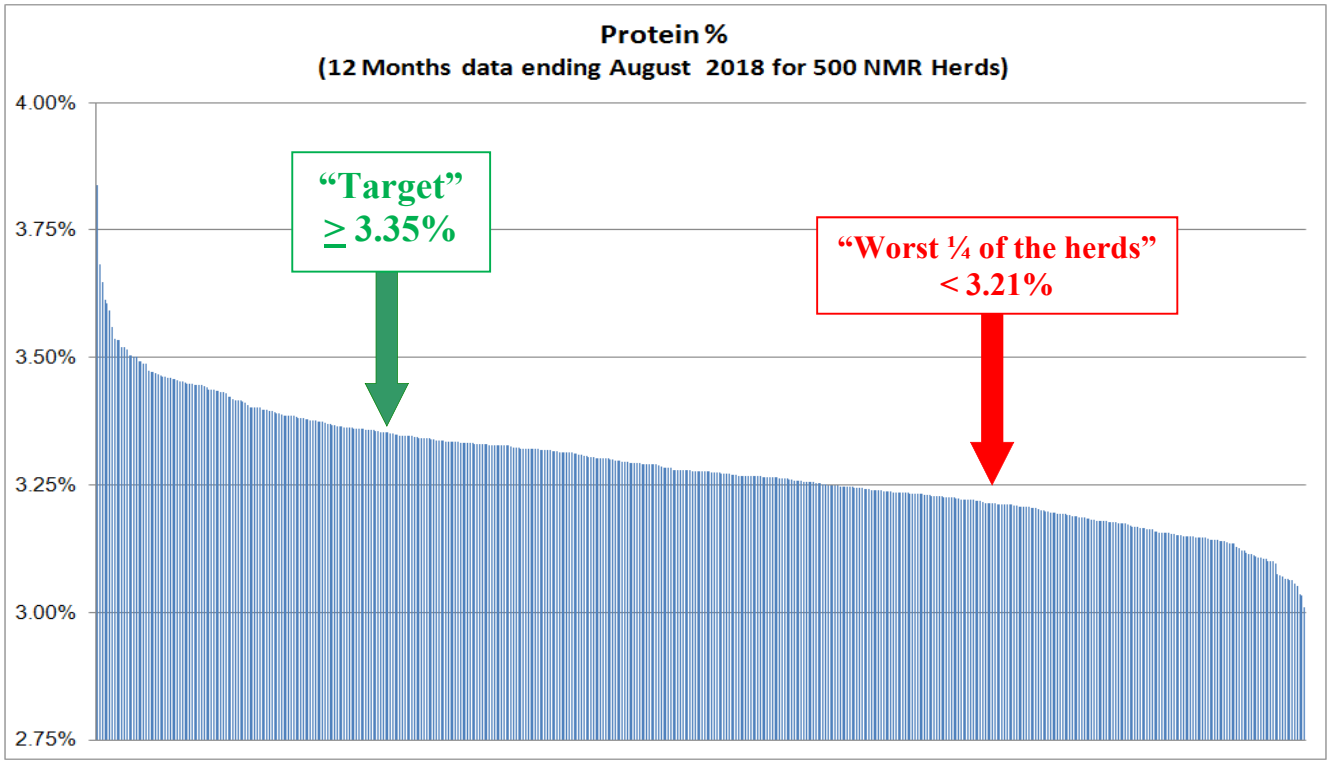
P. Milk / cow / year (kg): The average annual milk yield of all cows in the year. Total milk divided by the average cow population. A measure of milk yield per cow place in the herd.

Target (top ¼ of herds' level):	**9,487**
Median:	8,446
75% level:	7,315
Inter-quartile range:	2,172



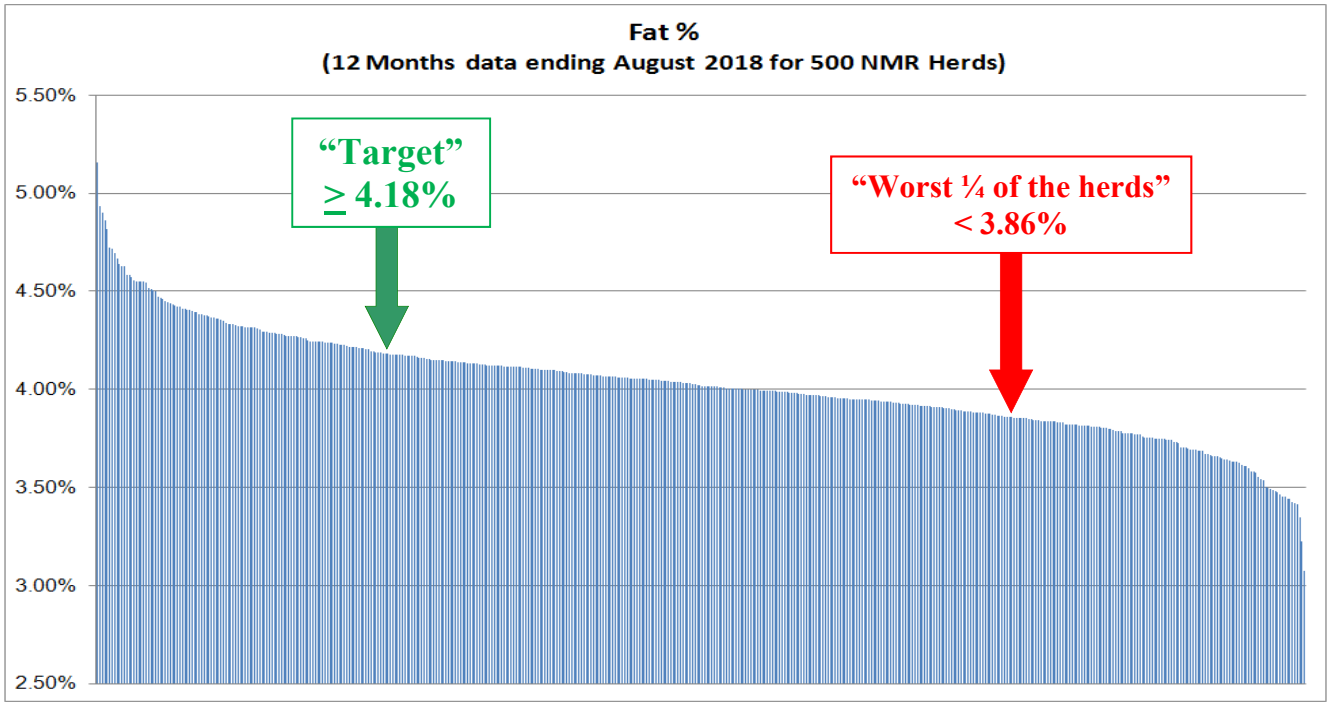
Q. Average protein%: The average % protein of all milk samples taken over the year.

Target (top ¼ of herds' level):	**3.35%**
Median:	3.28%
75% level:	3.21%
Inter-quartile range:	0.14%



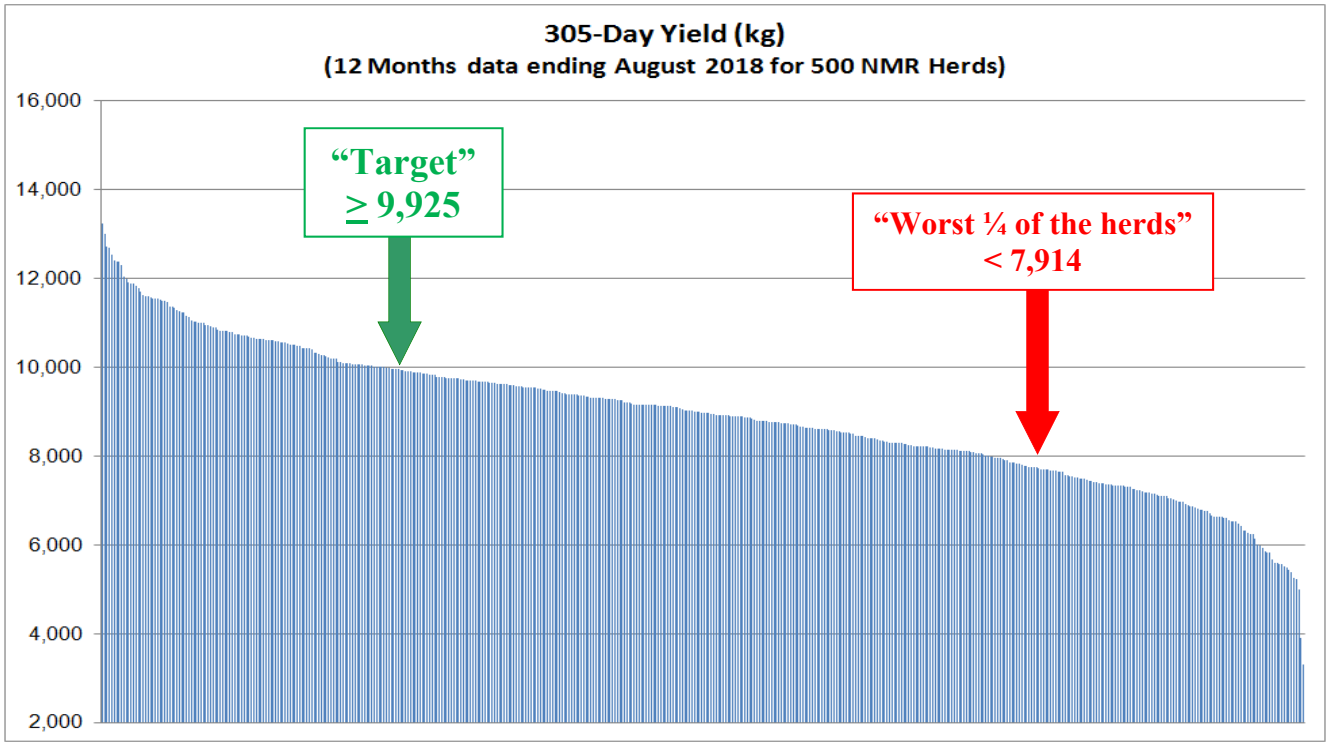
R. Average fat%: The average % fat of all milk samples taken over the year.

Target (top ¼ of herds' level):	**4.18%**
Median:	4.02%
75% level:	3.86%
Inter-quartile range:	0.32%



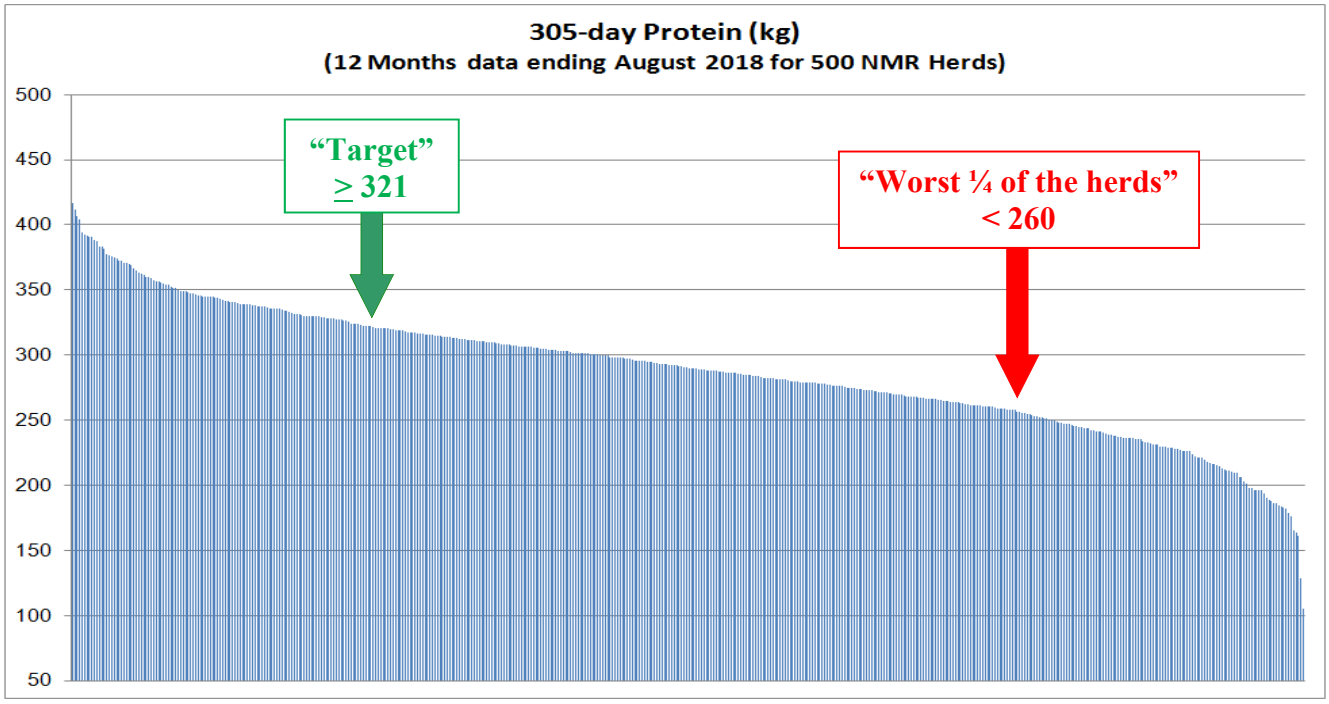
S. 305 day yield (kg): The average yield of cows by day 305 of the lactation.

Target (top ¼ of herds' level):	**9,925**
Median:	8,967
75% level:	7,914
Inter-quartile range:	2,011



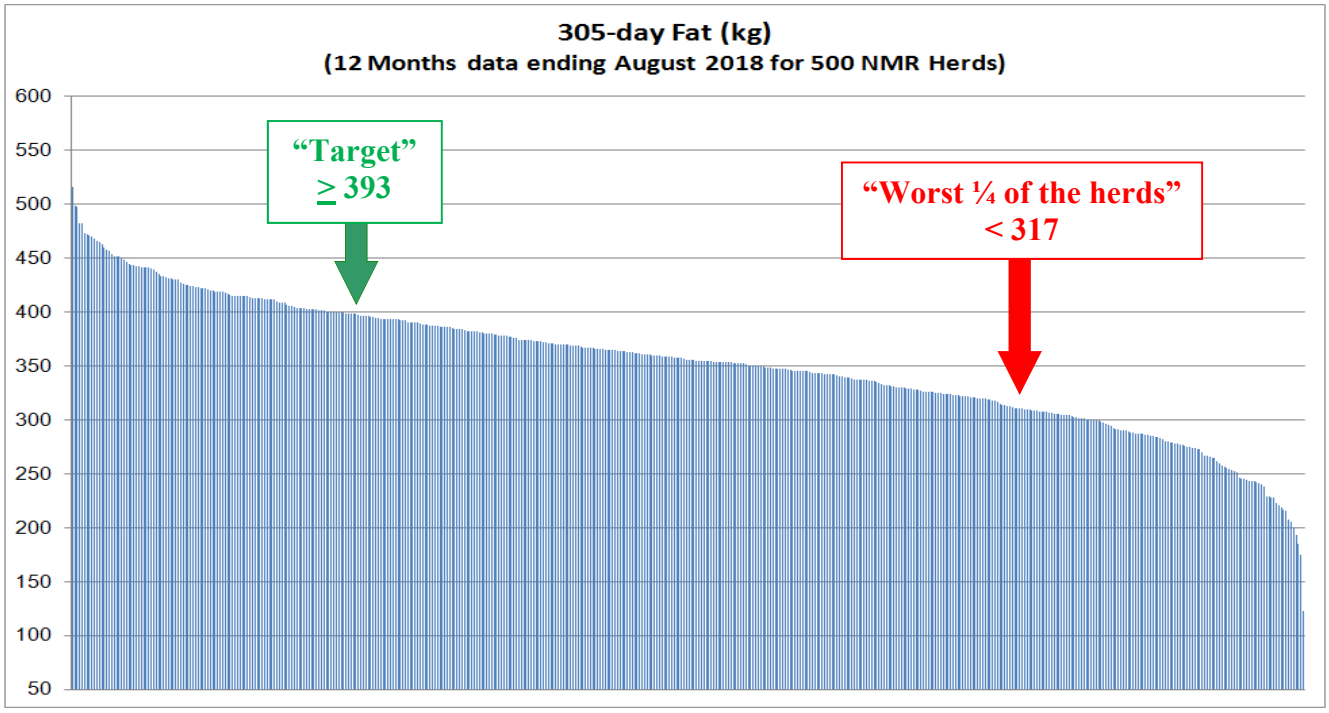
T. 305 day protein (kg): The average milk protein yield of cows by day 305 of the lactation.

Target (top ¼ of herds' level):	**321**
Median:	290
75% level:	260
Inter-quartile range:	61



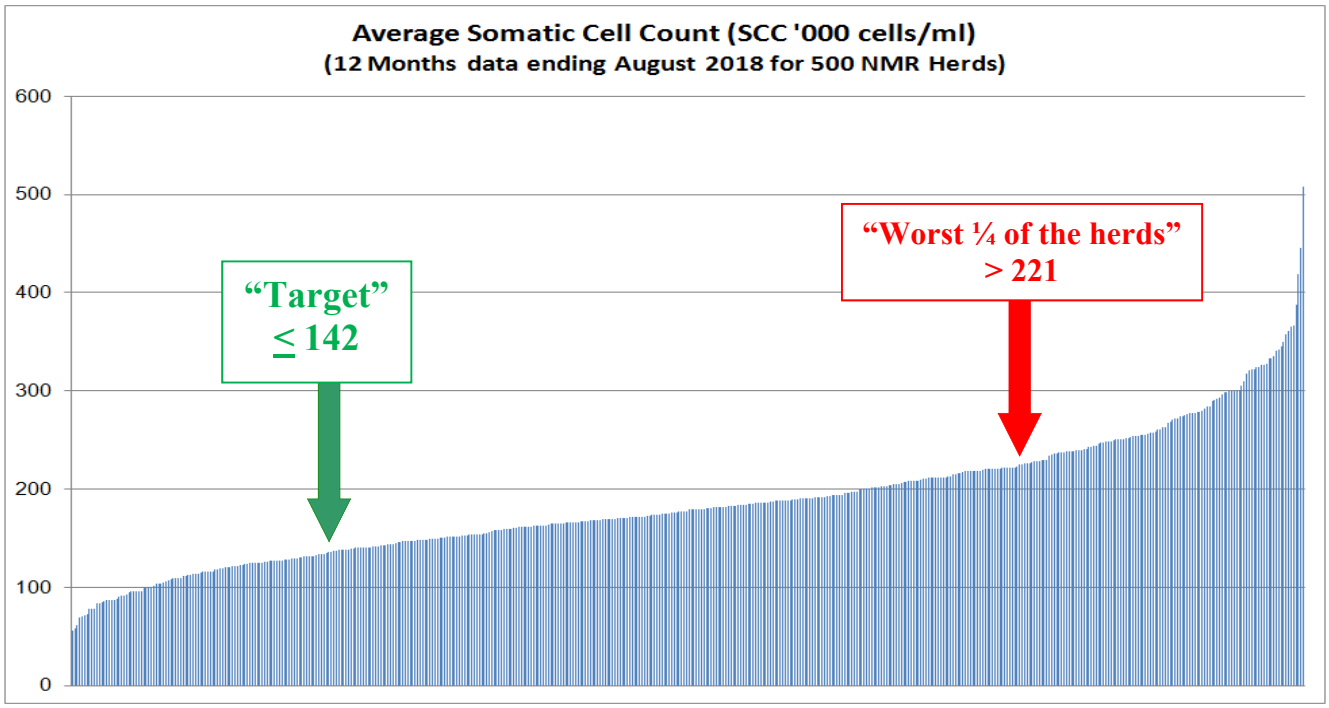
U. 305 day fat (kg): The average milk fat yield of cows by day 305 of the lactation.

Target (top ¼ of herds' level):	**393**
Median:	356
75% level:	317
Inter-quartile range:	76



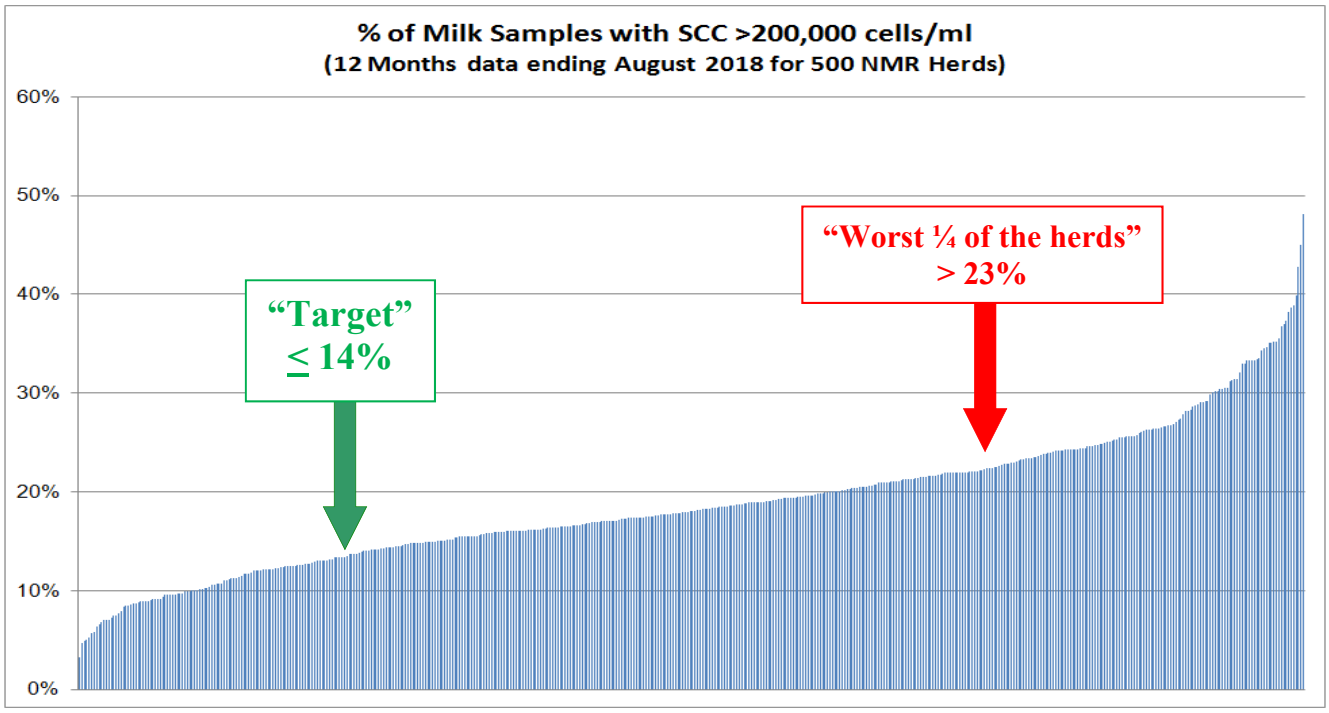
V. Herd SCC ('000 cells/ml): The weighted average SCC of all milk samples taken in the last 12 months.

Target (top ¼ of herds' level):	**142**
Median:	178
75% level:	221
Inter-quartile range:	79



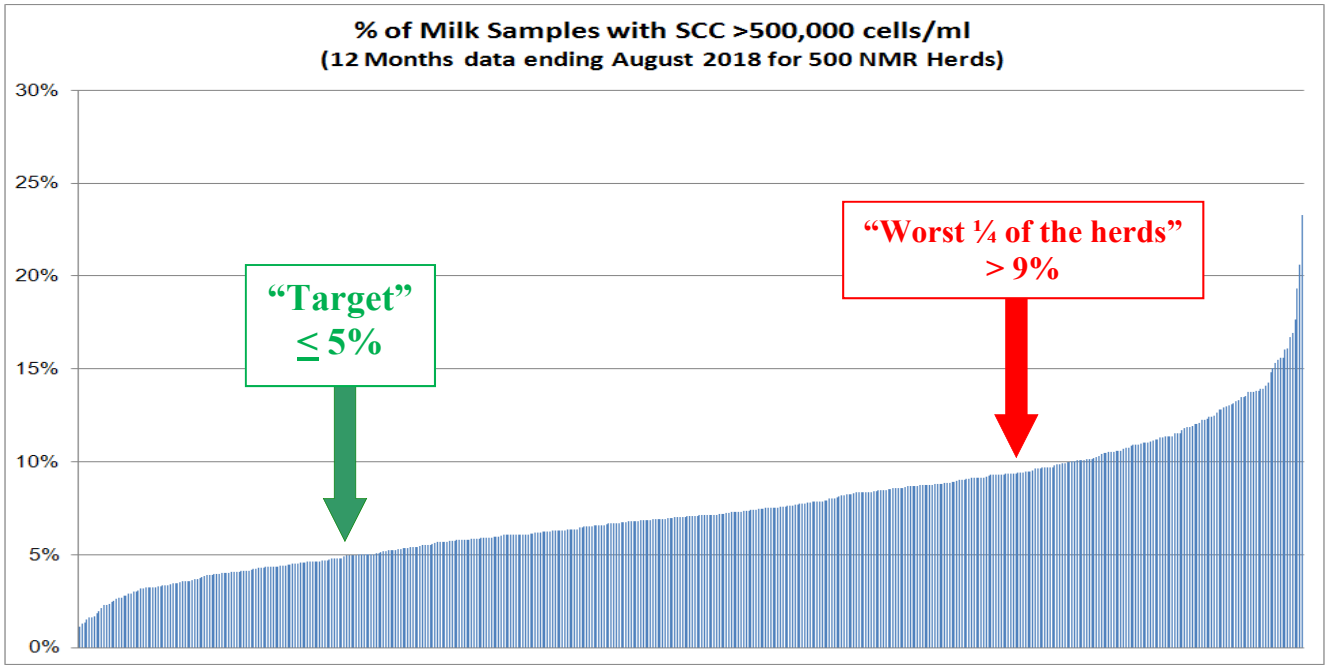
W. Percentage of milk samples with high SCC: The % of milk samples in the last 12 months with a SCC over 200,000 cells/ml of milk. Indicates the size of any reservoir of infection.

Target (top ¼ of herds' level):	**14%**
Median:	18%
75% level:	23%
Inter-quartile range:	9%



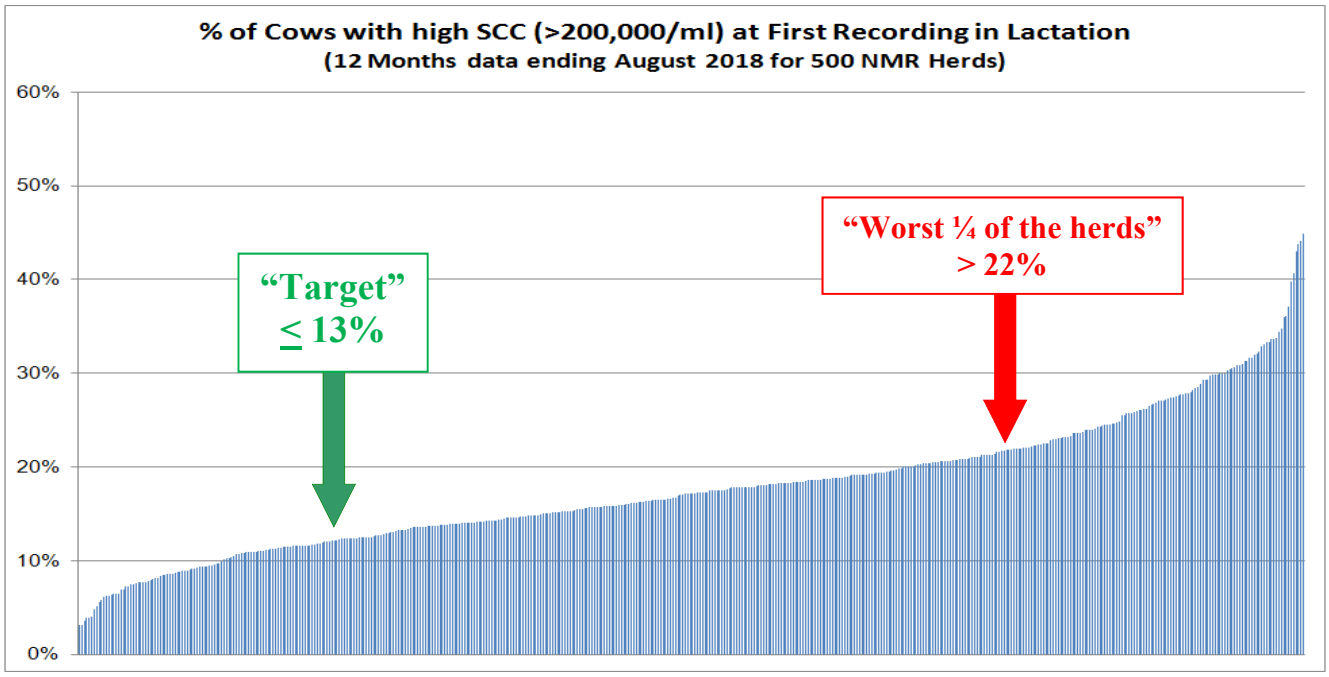
X. Percentage of milk samples with SCC >=500,000 cells/ml: The % of milk samples taken in the last 12 months with a SCC over 500,000 cells/ml of milk.

Target (top ¼ of herds' level):	**5%**
Median:	7%
75% level:	9%
Inter-quartile range:	4%



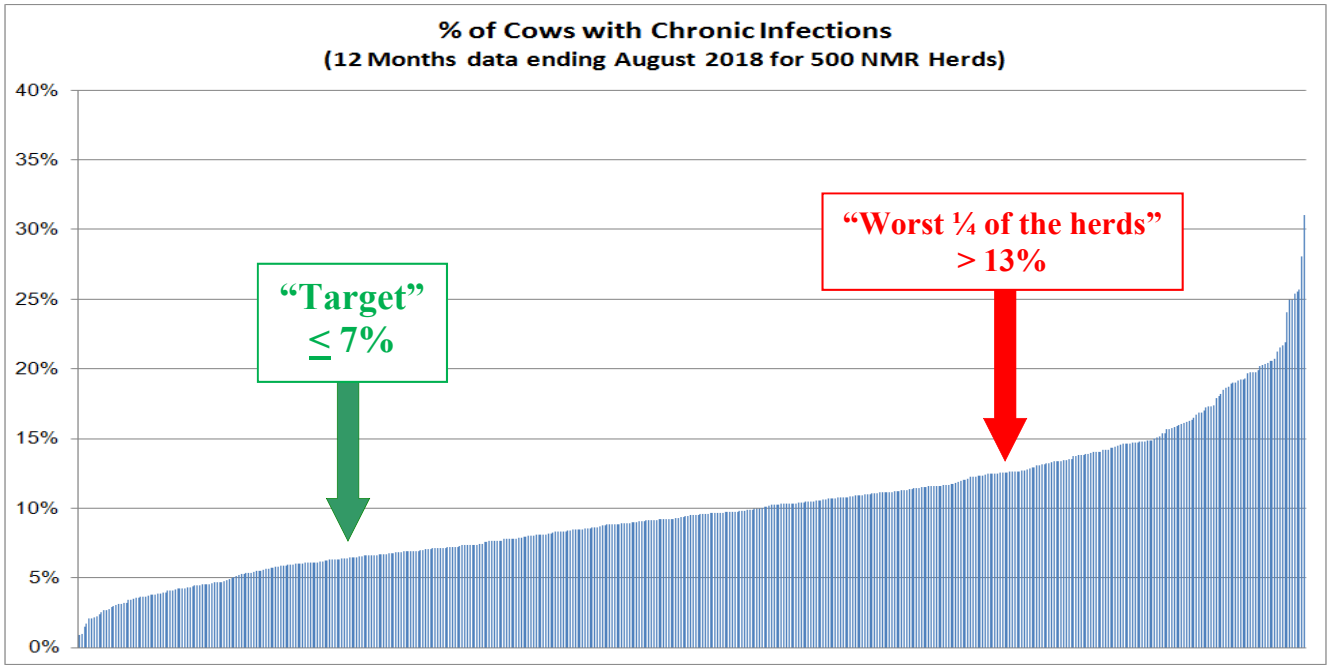
Y. Percentage 1st recording SCC >=200,000 cells/ml: The % of new lactations in the last year starting with a high SCC (>=200,000 cells) at the first milk recording.

Target (top ¼ of herds' level):	**13%**
Median:	17%
75% level:	22%
Inter-quartile range:	9%



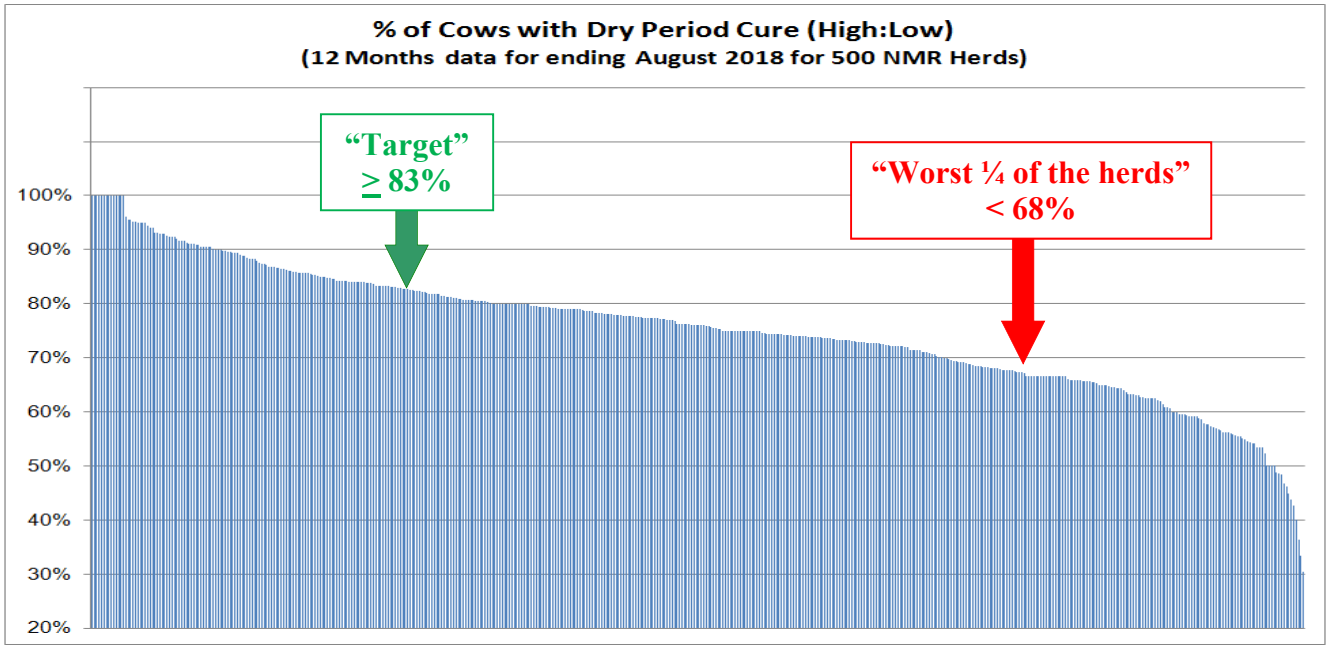
Z. Percentage chronic SCC >=200,000 cells/ml: The % of all milk samples taken over the last 12 months that were from CHRONIC cows (cows whose milk was over 200,000 cells at both the CURRENT AND PREVIOUS milk recordings).

Target (top ¼ of herds' level):	**7%**
Median:	10%
75% level:	13%
Inter-quartile range:	6%



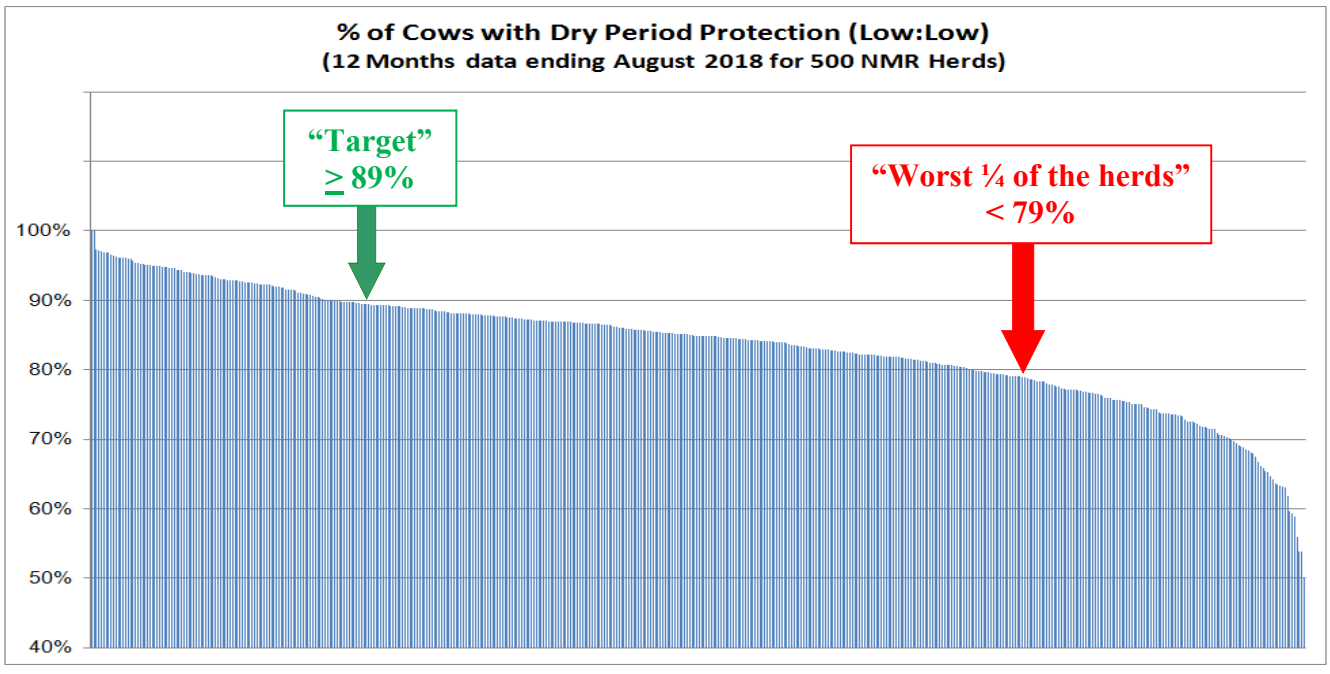
ZA. Dry period cure (High:Low): The % of cows calving in the last year that ended their previous lactation with a high SCC (>=200,000 cells), started the new lactation with a LOW cell count (<200,000 cells). The % of high SCC cows "cured" in the dry period.

Target (top ¼ of herds' level):	**83%**
Median:	76%
75% level:	68%
Inter-quartile range:	15%



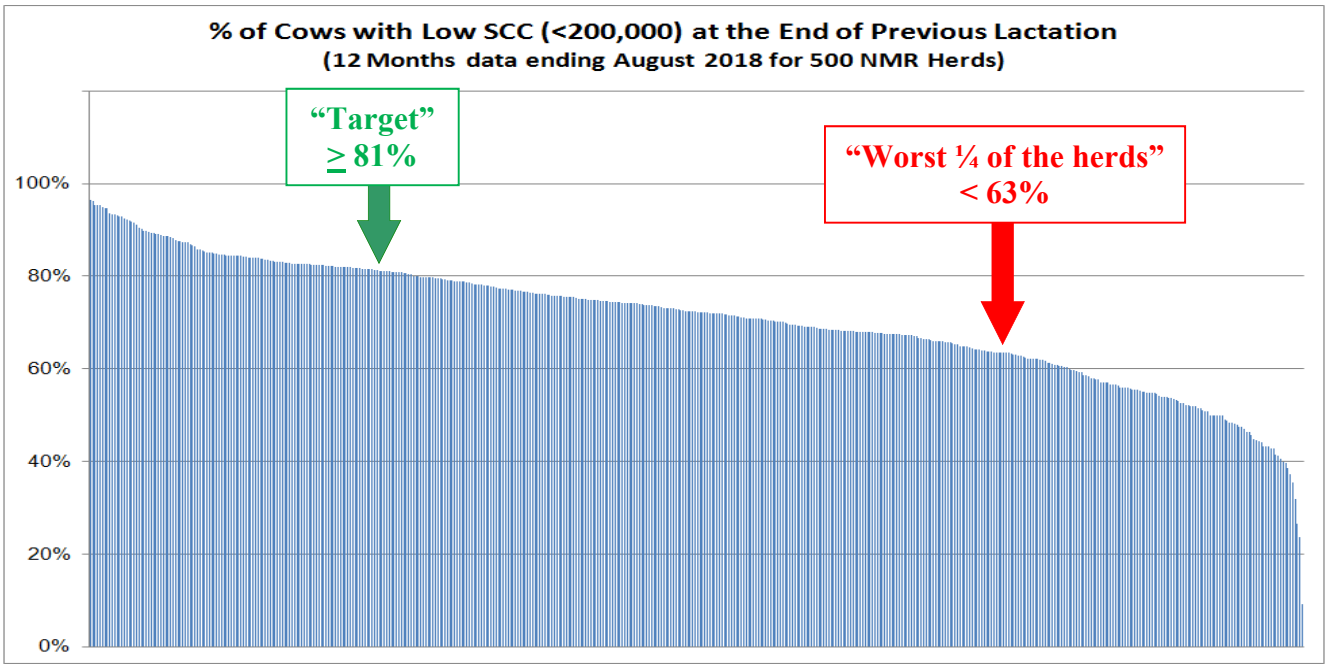
ZB. Dry period protection (Low:Low): The % of cows calving in the last year that ended the previous lactation with a LOW SCC (<200,000 cells) then started the new lactation with a LOW cell count (<200,000 cells). The % of low SCC cows "protected" in the dry period.

Target (top ¼ of herds' level):	**89%**
Median:	85%
75% level:	79%
Inter-quartile range:	10%



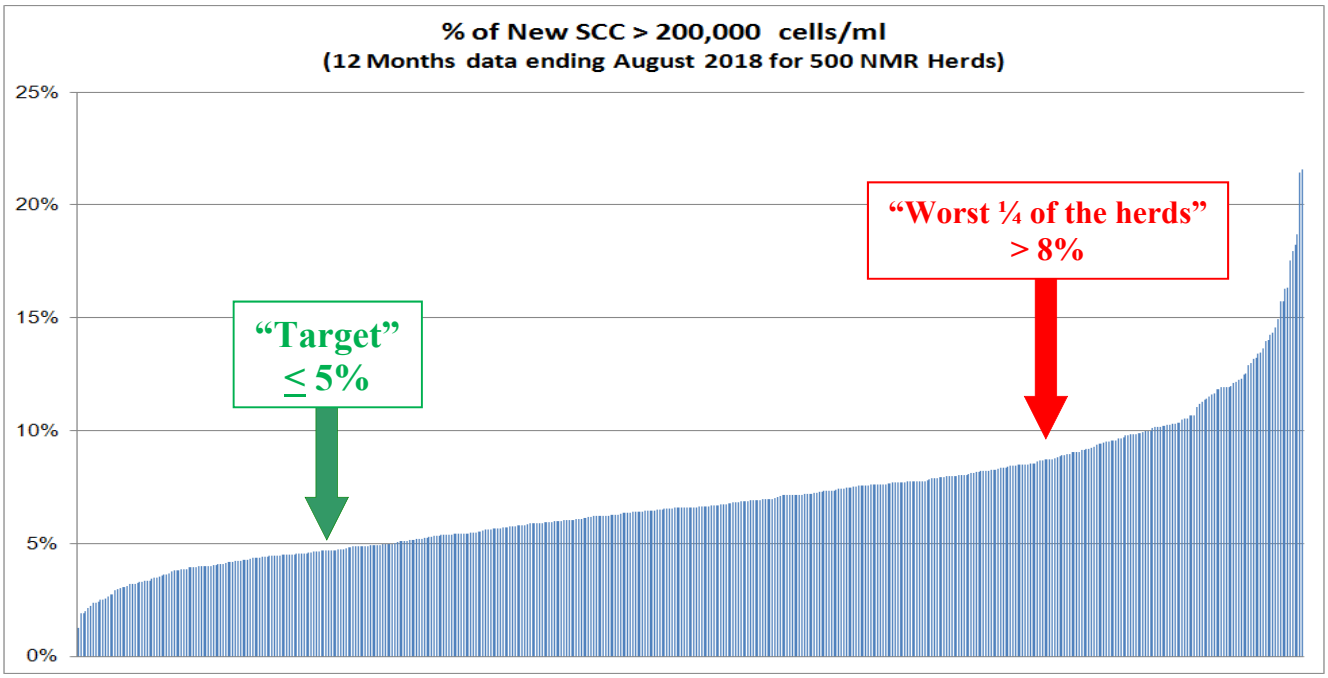
ZC. Percentage Low at the end of previous lactation: The % of cows calving in the last year that ended their previous lactation with a LOW SCC (<200,000 cells).

Target (top ¼ of herds' level):	**81%**
Median:	72%
75% level:	63%
Inter-quartile range:	18%



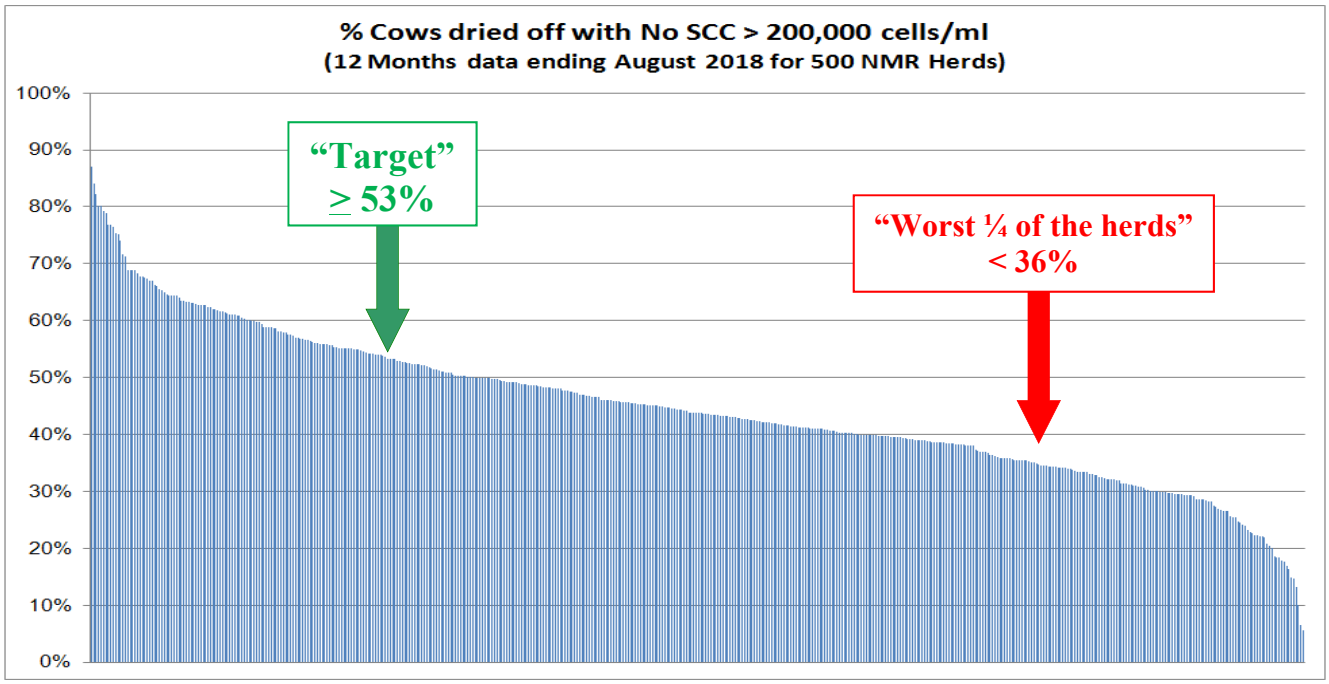
ZD. The percentage of NEW SCC milk samples: Of all milk samples the % that were of the NEW Herd Companion SCC Category (the first HIGH SCC (>=200,000cells/ml) in a lactation following one or more low SCC samples).

Target (top ¼ of herds' level):	**5%**
Median:	7%
75% level:	8%
Inter-quartile range:	3%



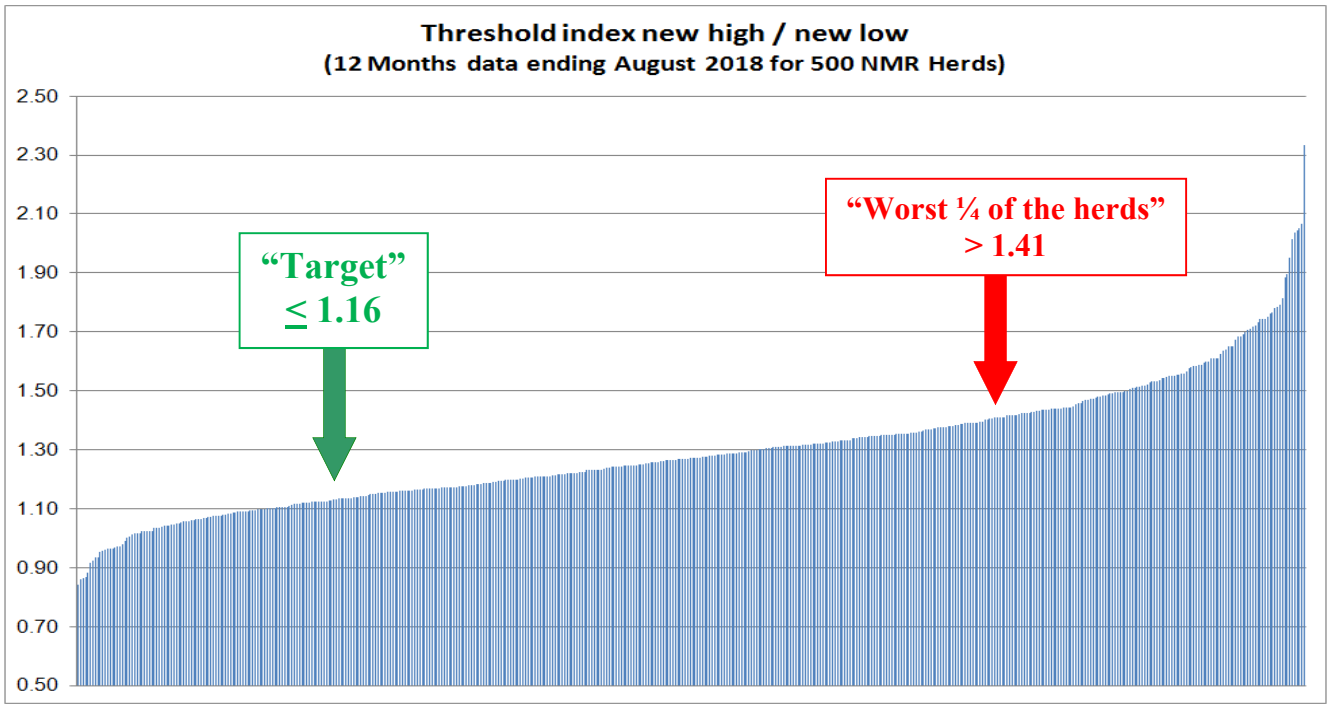
ZE. Percentage Dried-off with no SCC >=200,000 cells/ml: The percentage of cows recording only LOW SCC samples (<200,000 cells/ml) in completed lactations.

Target (top ¼ of herds' level):	**53%**
Median:	44%
75% level:	36%
Inter-quartile range:	17%



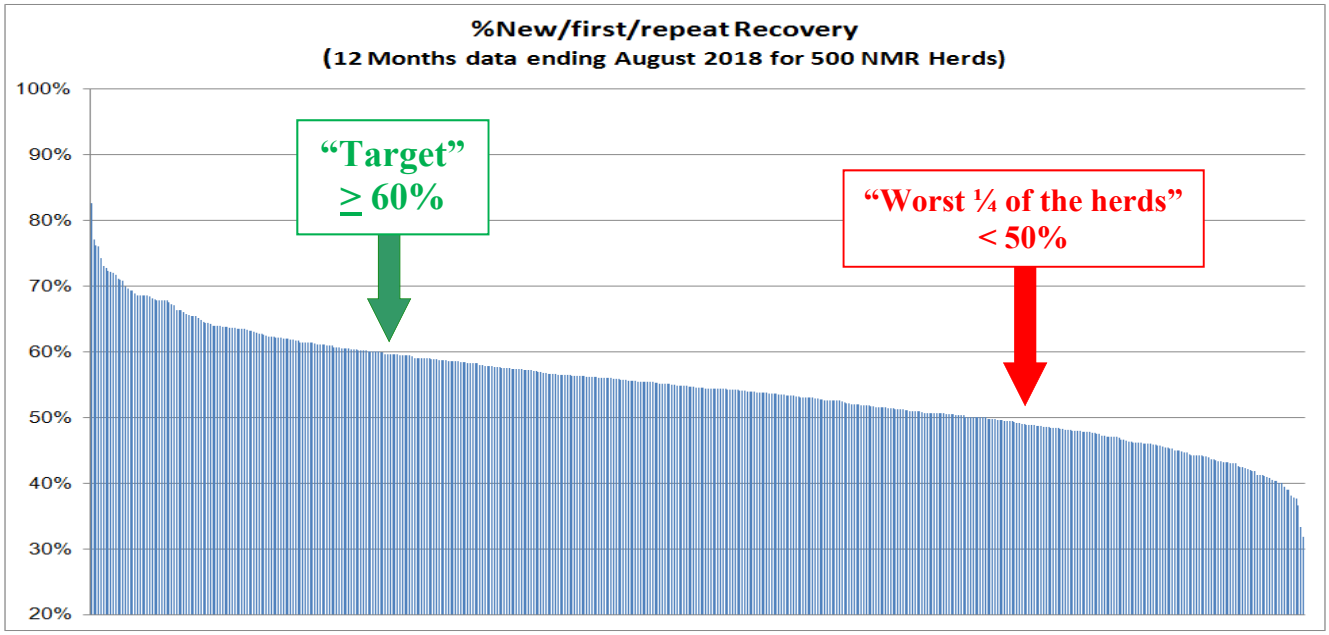
ZF. Threshold Index new high / new low: The total cows changing from Low to High SCC divided by the total cows changing from High to Low SCC at consecutive recordings.

Target (top ¼ of herds' level):	**1.16**
Median:	1.27
75% level:	1.41
Inter-quartile range:	0.25



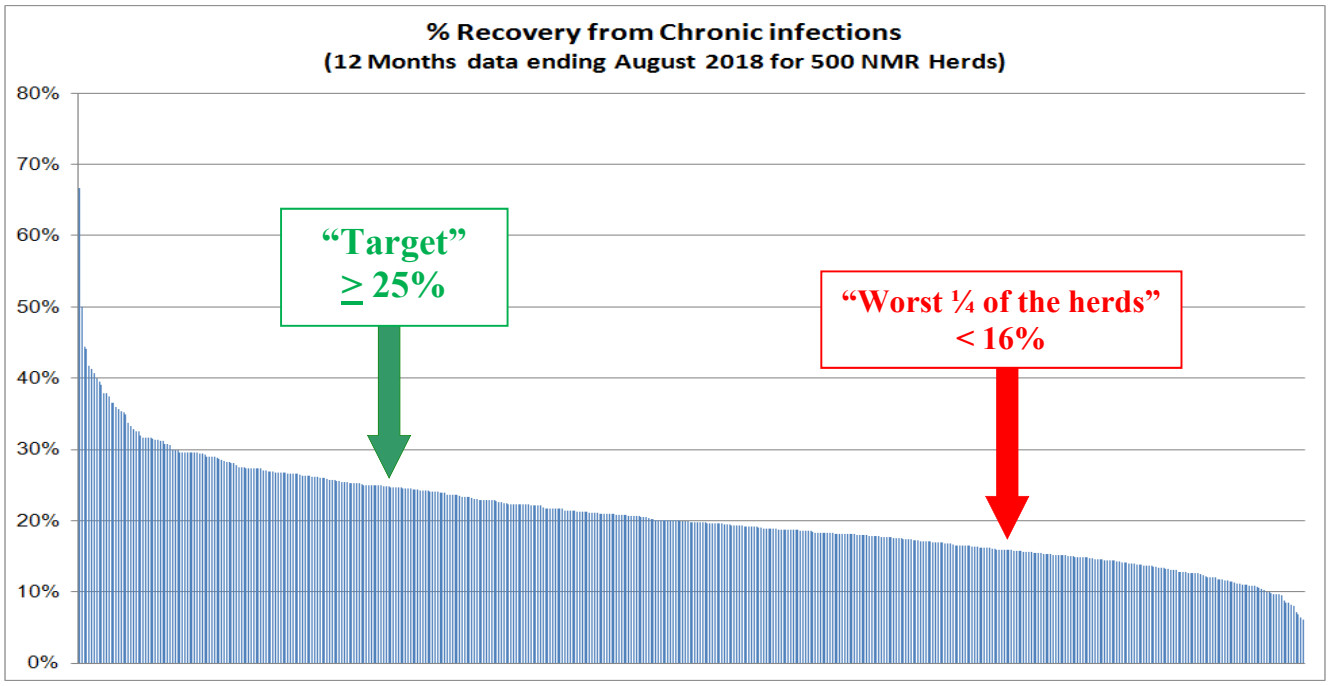
ZG. Recovery percentage of New/First/Repeat infections: Of HIGH SCC cows (>=200,000cells/ml) that at the previous recording were either low SCC or not yet in milk, the percentage that were LOW SCC (<200,000 cells/ml) at the following recording.

Target (top ¼ of herds' level):	**60%**
Median:	55%
75% level:	50%
Inter-quartile range:	10%



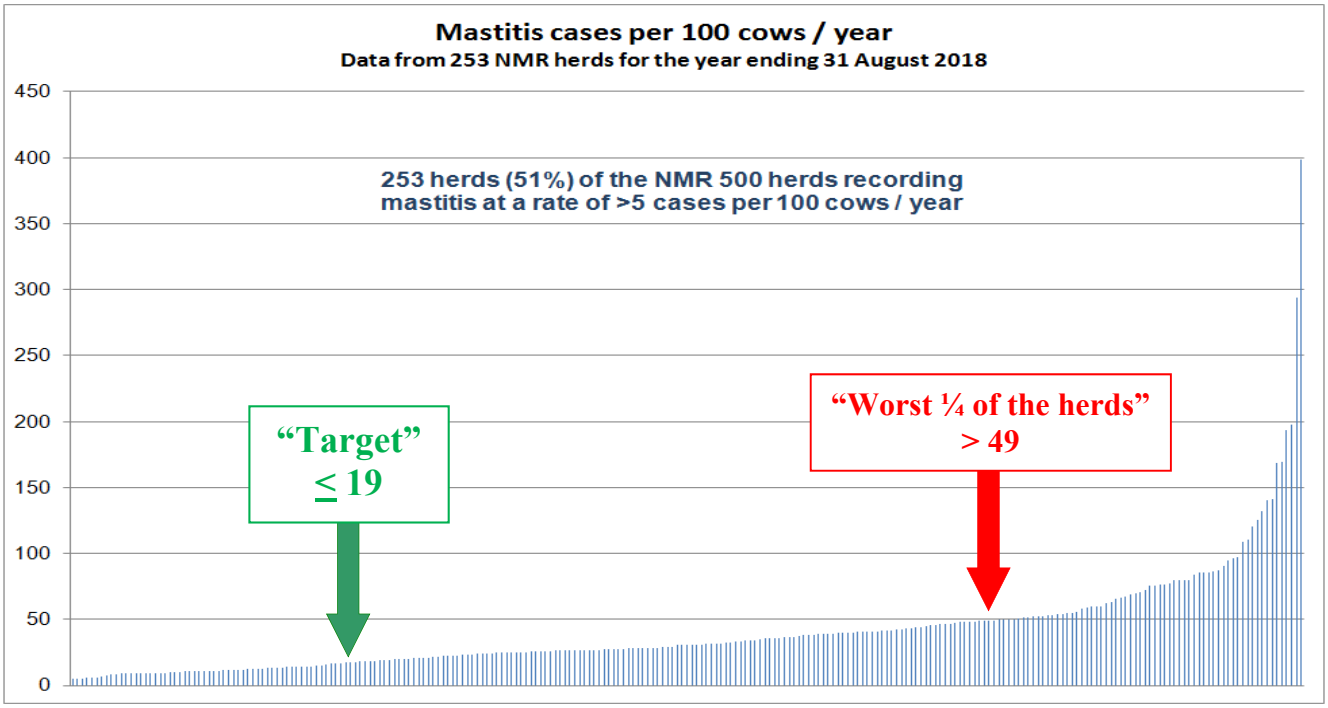
ZH. Recovery percentage of chronic infections: Of cows with two or more consecutive HIGH SCC recordings (>=200,000 cells/ml), the percentage that recorded a LOW SCC (<200,000 cells/ml) at the following recording.

Target (top ¼ of herds' level):	**25%**
Median:	20%
75% level:	16%
Inter-quartile range:	9%



ZJ. Mastitis rate: Number of clinical mastitis cases per 100 cows in milk in the herd over a year.

Target (top ¼ of herds' level):	**19**
Median:	31
75% level:	49
Inter-quartile range:	30



Section 3: Trends in Key Performance Indicators 2010 to 2018

The target and median figures from the current study are compared with the results from the first study for the year ending 30th September 2010. Table 2 below shows changes in the median and target (top 25% performance) values for each parameter over the eight years period. The majority of parameters have improved (green) over the period with the exception of age & number of lactations at exit which show slight deterioration (red). There is no attempt at identifying any statistical significance in these changes.

Table 2. Comparison of median and target values derived from the study of 500 NMR recording herds in 2018 with the original study in 2010

Parameter	**Median**	**Median**		**Target "Best 25%"**	**Target "Best 25%"**
Year of the Study	***2010***	***2018***		***2010***	***2018***
A. Culling rate	24%	27%		18%	22%
B. Percentage culled / died 100 days after calving	7%	6%		4%	4%
C. Age at exit (years)	6.6	6.0		7.4	6.7
D. Age at exit by lactations	3.9	3.6		4.5	4.1
E. Percentage Served by day 80	46%	57%		59%	68%
F. Percentage conceived 100 days after calving	26%	34%		33%	41%
G. Calving to 1st service interval (days)	105	81		87	71
H. Calving interval (days)	424	400		409	388
I. Age at 1st calving (years)	2.4	2.3		2.3	2.1
J. Conception rate	32%	35%		40%	42%
K. %Service intervals at 18-24 days (Heat detection)	30%	35%		38%	42%
L. %Service intervals >50 days	32%	23%		22%	16%
M. %Cows eligible for service served (Submission rate)	27%	37%		37%	49%
N. %Cows eligible for service conceived (Pregnancy rate)	9%	13%		13%	17%
O. Lifetime milk / cow / day (kg)	10.5	12.5		12.6	14.7
P. Milk / cow / year (kg)	7,665	8,446		8,760	9,487
Q. Average protein%	3.27%	3.28%		3.33%	3.35%
R. Average fat%	3.96%	4.02%		4.12%	4.18%
V. Average SCC ('000 cells/ml)	210	178		169	142
W. Percentage SCC >=200,000 cells/ml	24%	18%		19%	14%
X. Percentage SCC >=500,000 cells/ml	9%	7%		7%	5%
Y. Percentage 1st recording SCC >=200,000 cells/ml	20%	17%		15%	13%
Z. Percentage chronic SCC >=200,000 cells/ml	14%	10%		10%	7%
ZA. Percentage Dry period cure (High:Low)	74%	76%		80%	83%
ZB. Percentage Dry period protection (Low:Low)	84%	85%		89%	89%
ZC. Percentage Low at end of previous lactation (SCC<200,000 cells/ml)	60%	72%		70%	81%

Changes in Key Parameters over the 9 annual KPI studies

The Figures below show the changes over the ninth annual KPI studies (2010 to 2018) for a number of important parameters. The three lines represent the "better" quartile, median and "poorer" quartile values each year for each parameter.

3.1 Trends in Culling & Longevity Parameters over the last 9 years

Figure 3. Culling rate

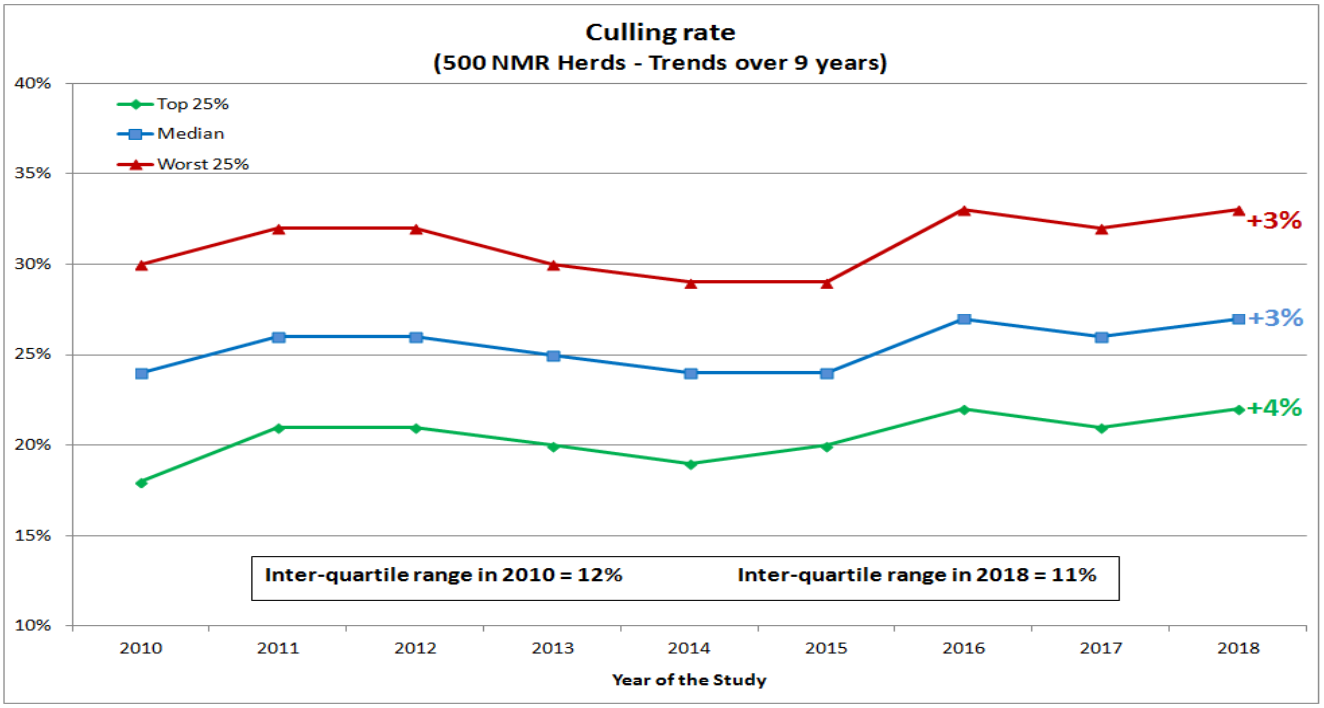


Figure 4. Culling in the first 100 days of lactation

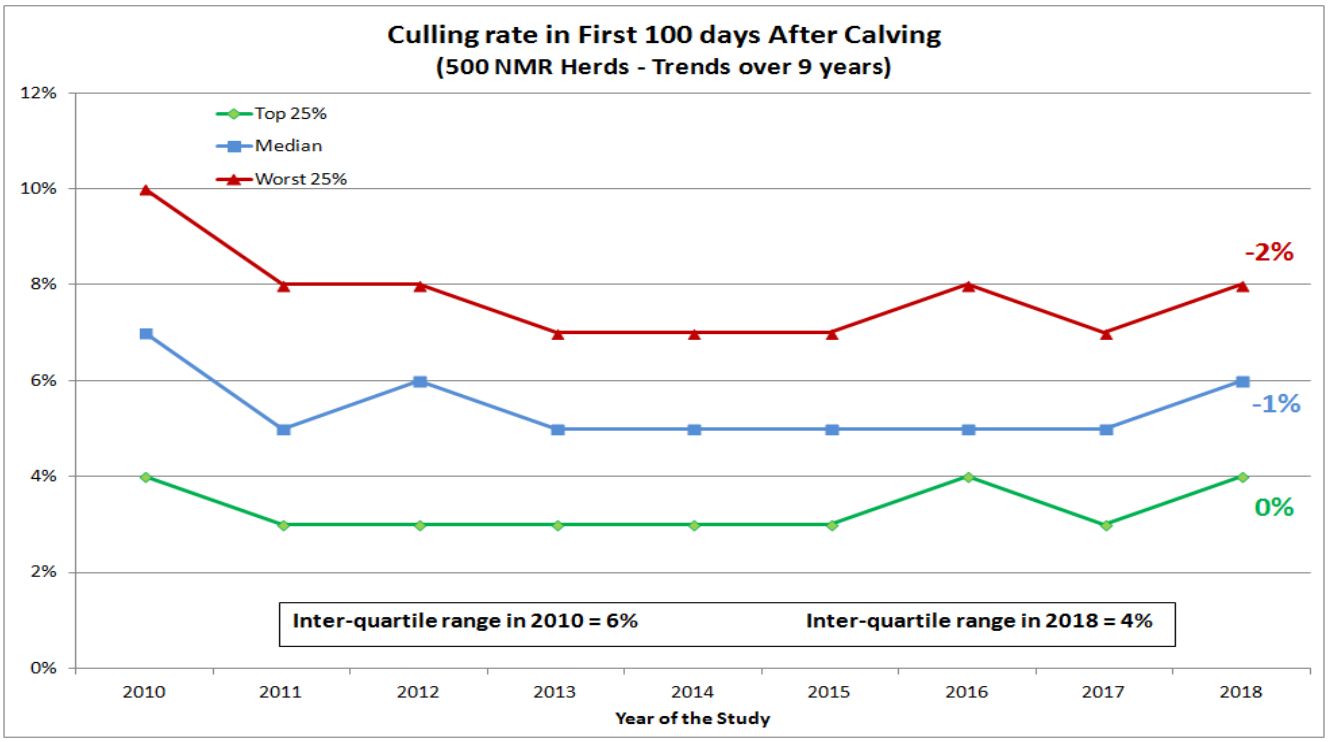


Figure 5. Age at exit (by number of Years)

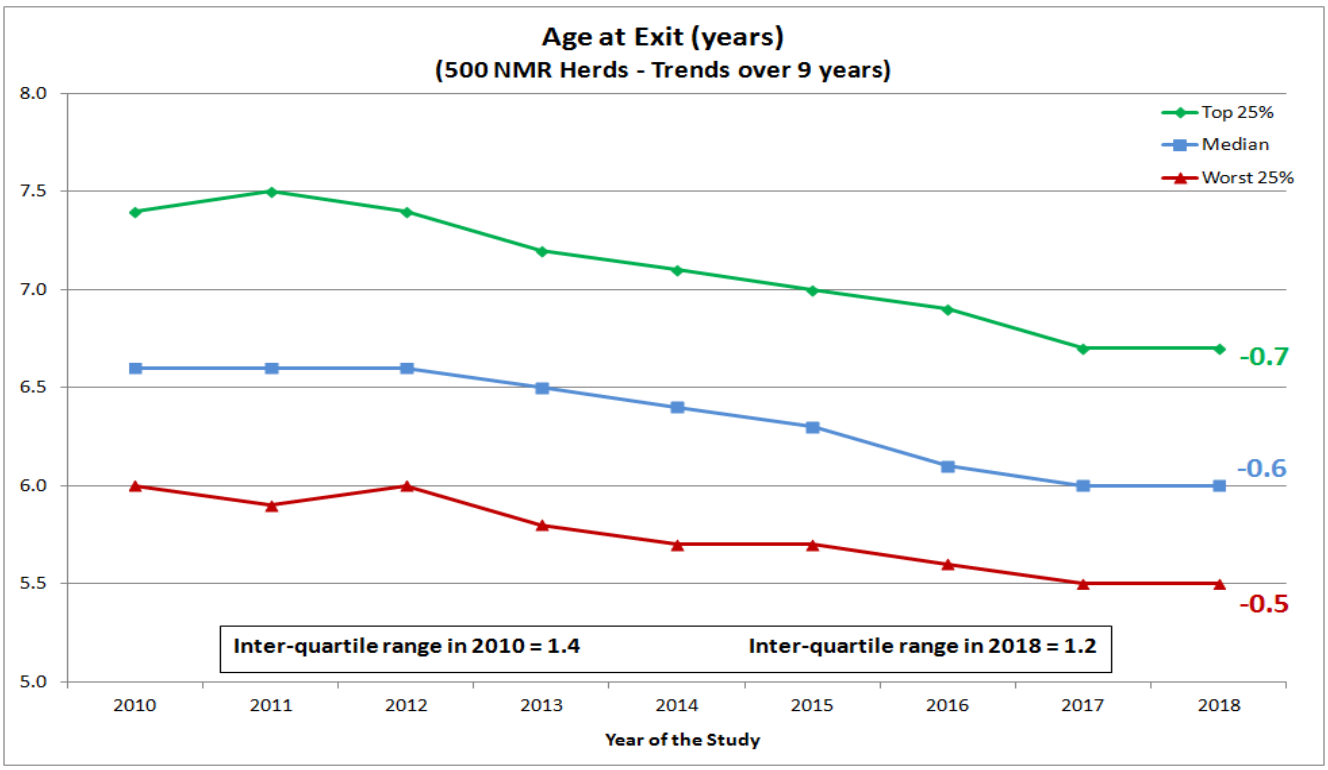
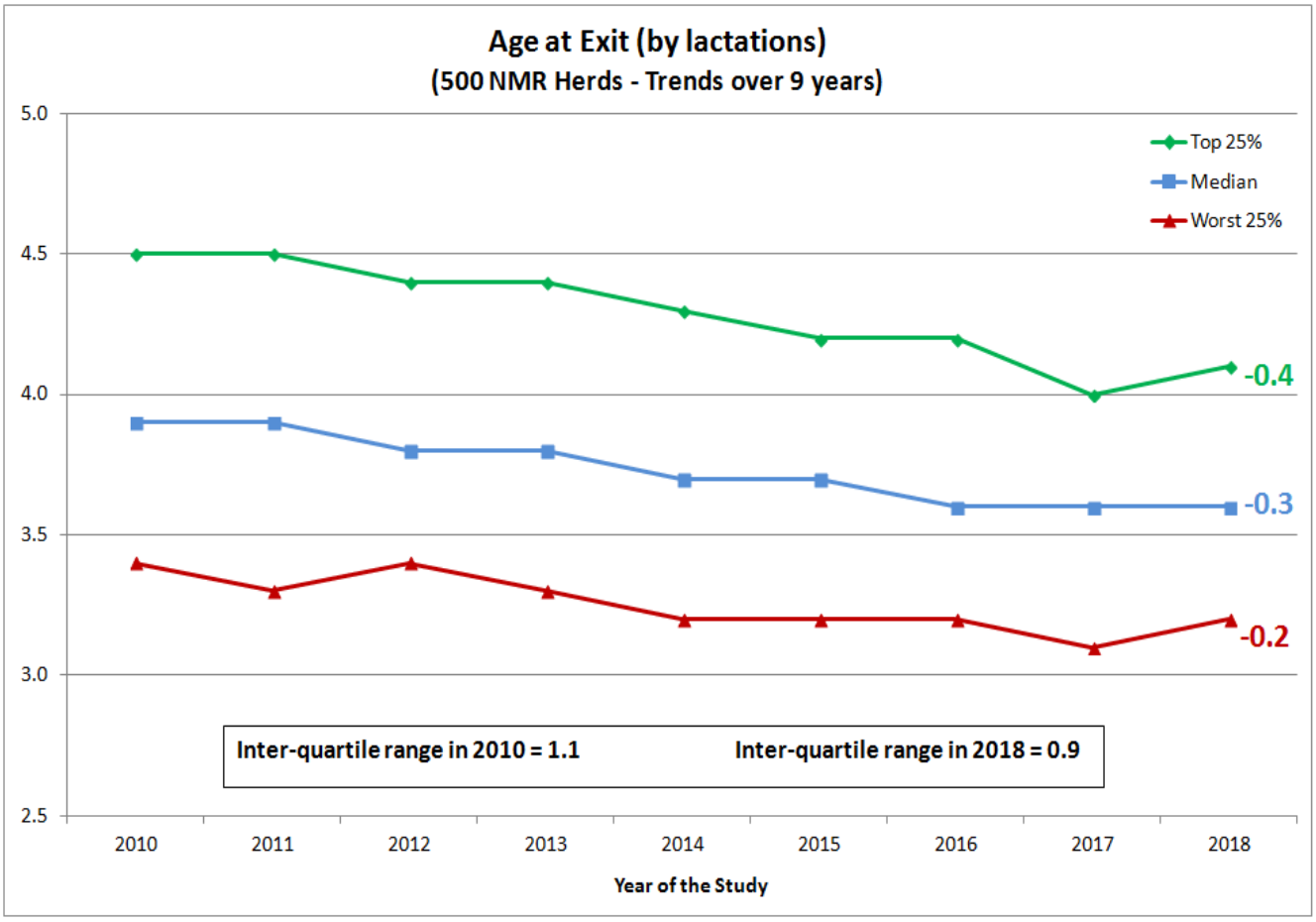


Figure 6. Age at exit (by number of Lactations)



3.2 Trends in Key Fertility Parameters over the last 9 years

Figure 7. Percentage of cows served by Day 80 after calving

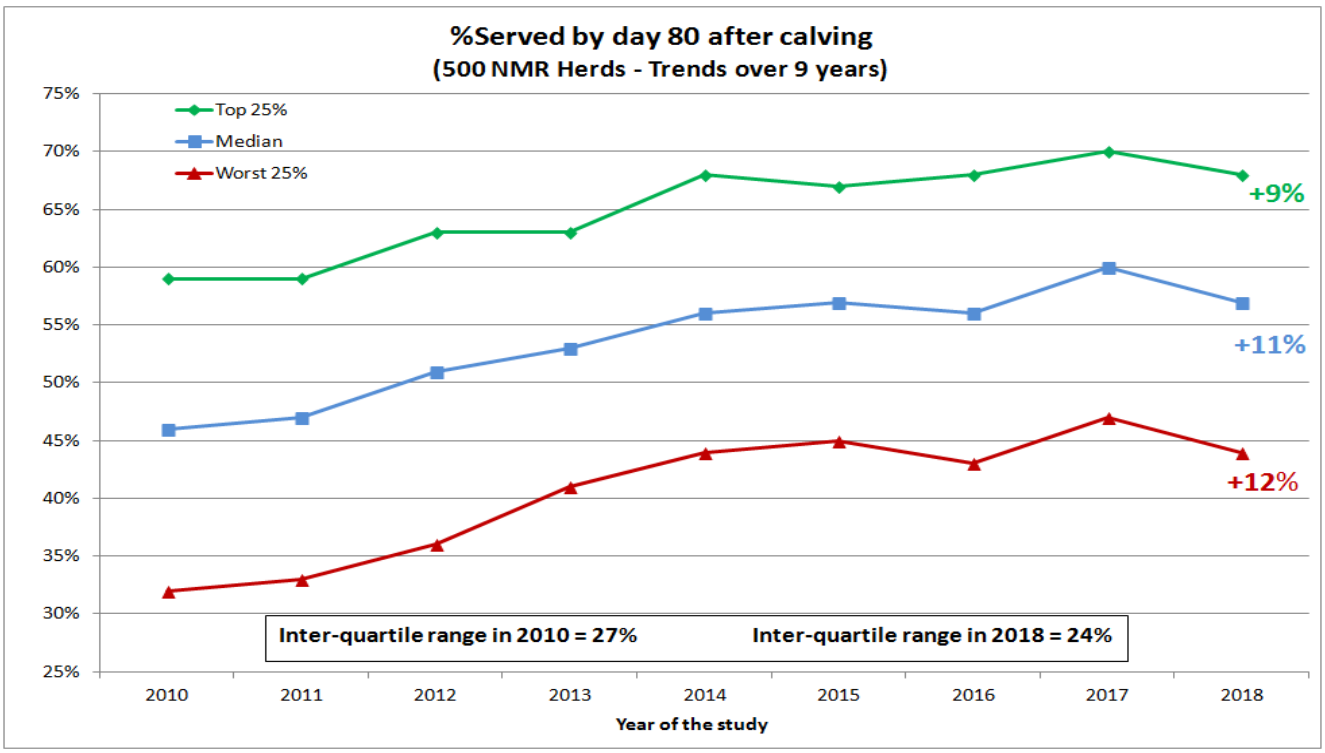


Figure 8. Percentage of cows pregnant (conceived) by Day 100 after calving

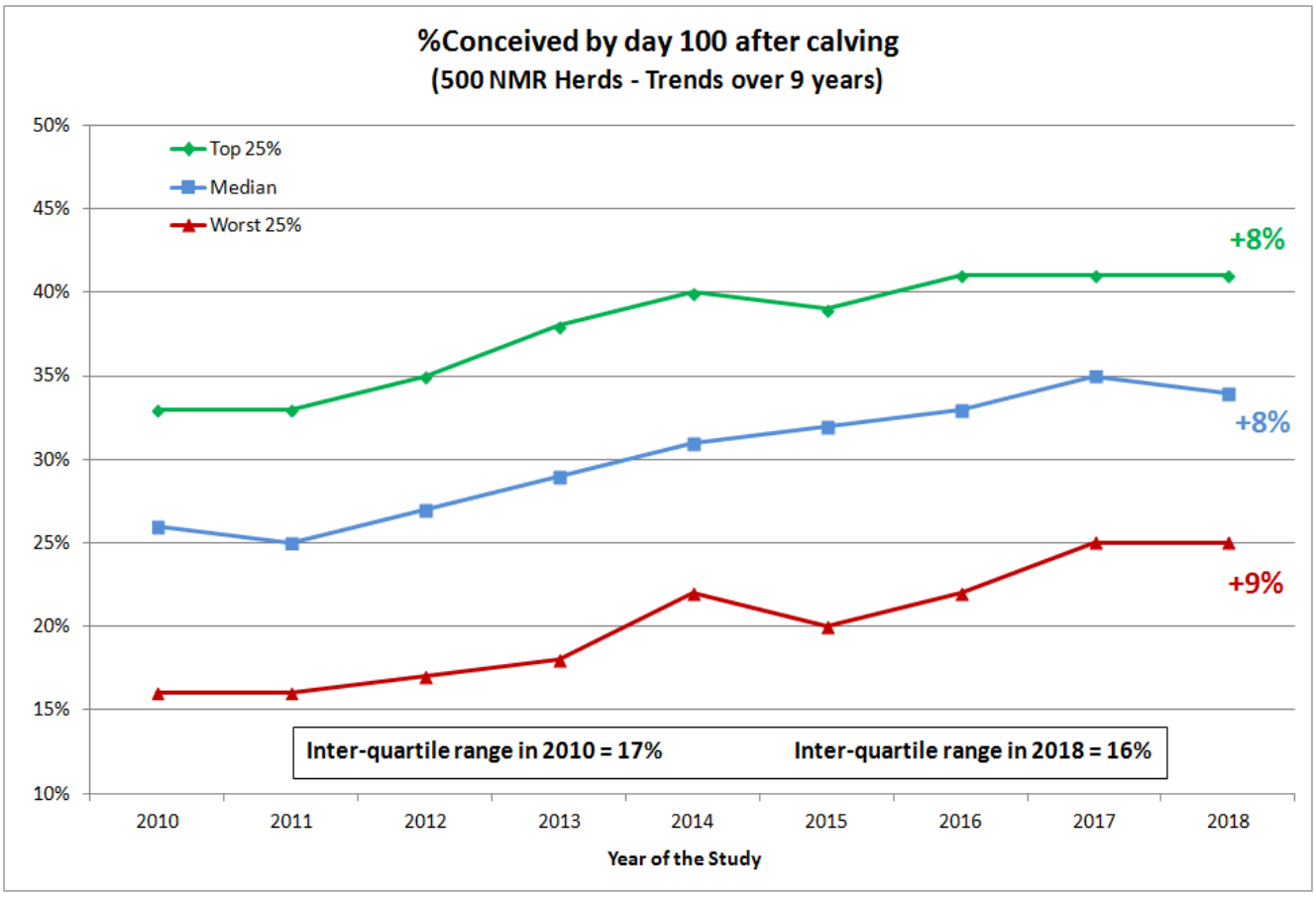


Figure 9. Percentage of all repeat services that are 18-24 days after the previous service (Heat detection)

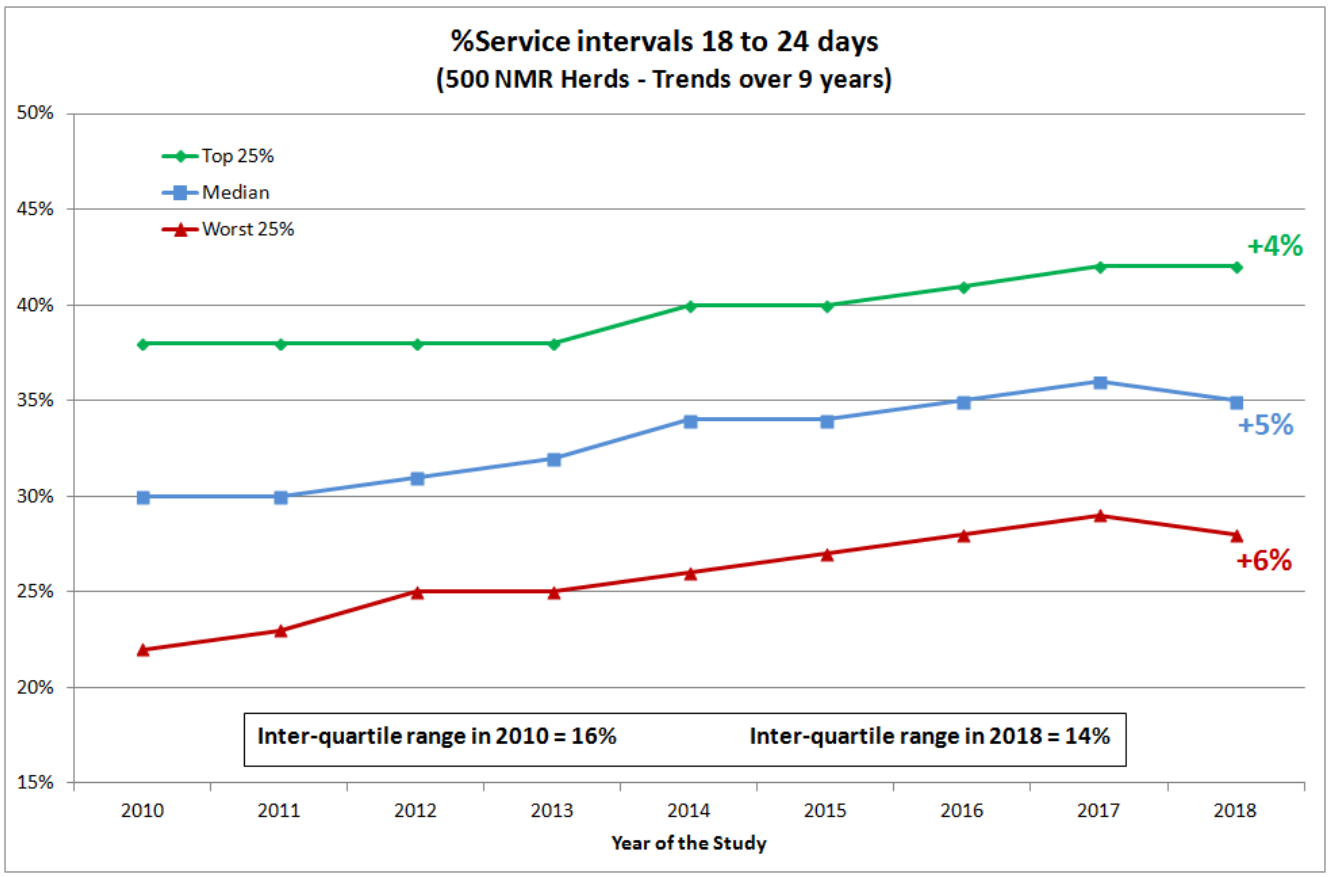
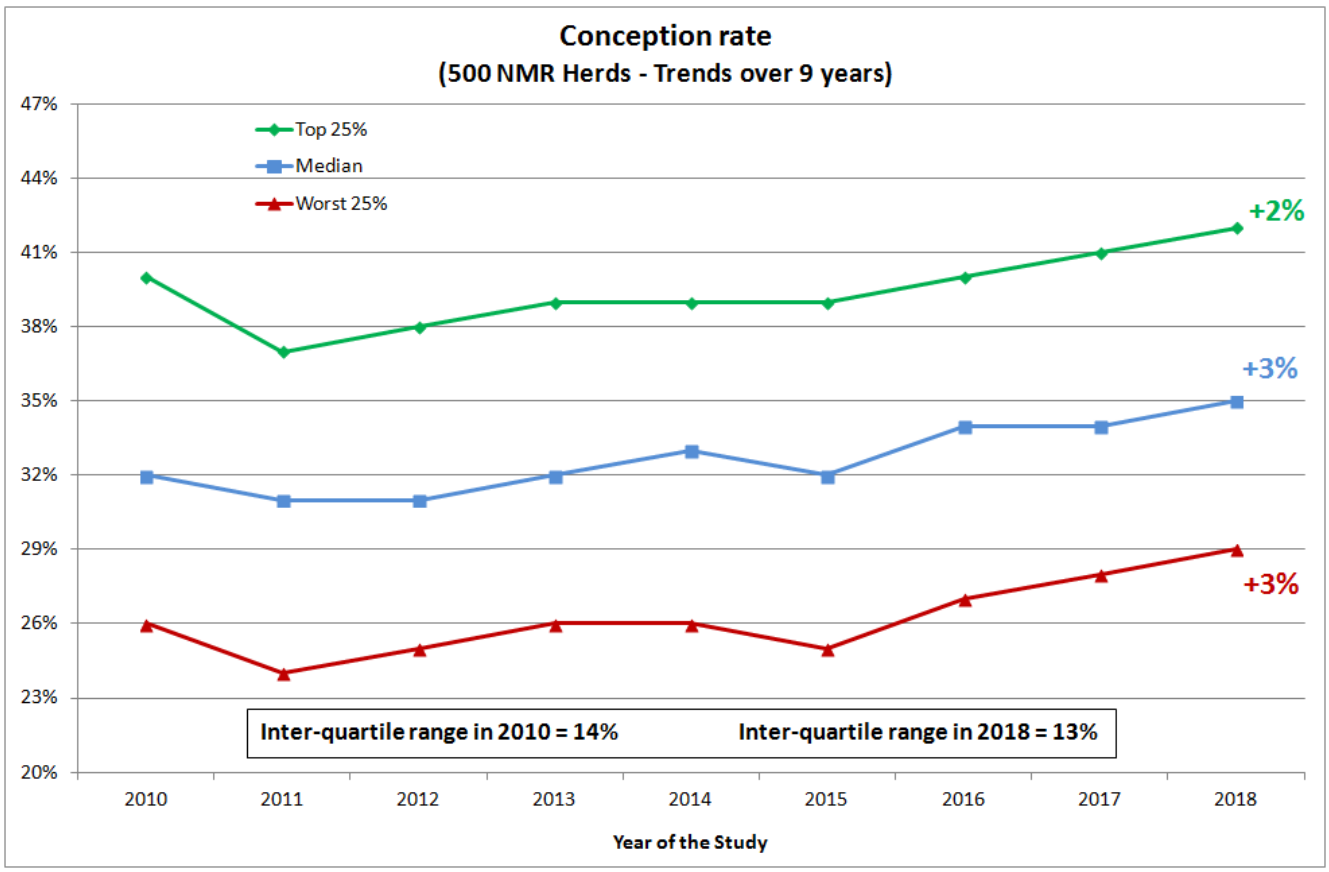


Figure 10. Percentage of all service resulting in a conception



3.3 Trends in Milk Production Parameters over the last 9 years

Figure 11. Lifetime milk per cow / day (kg). This includes days between birth and first calving.

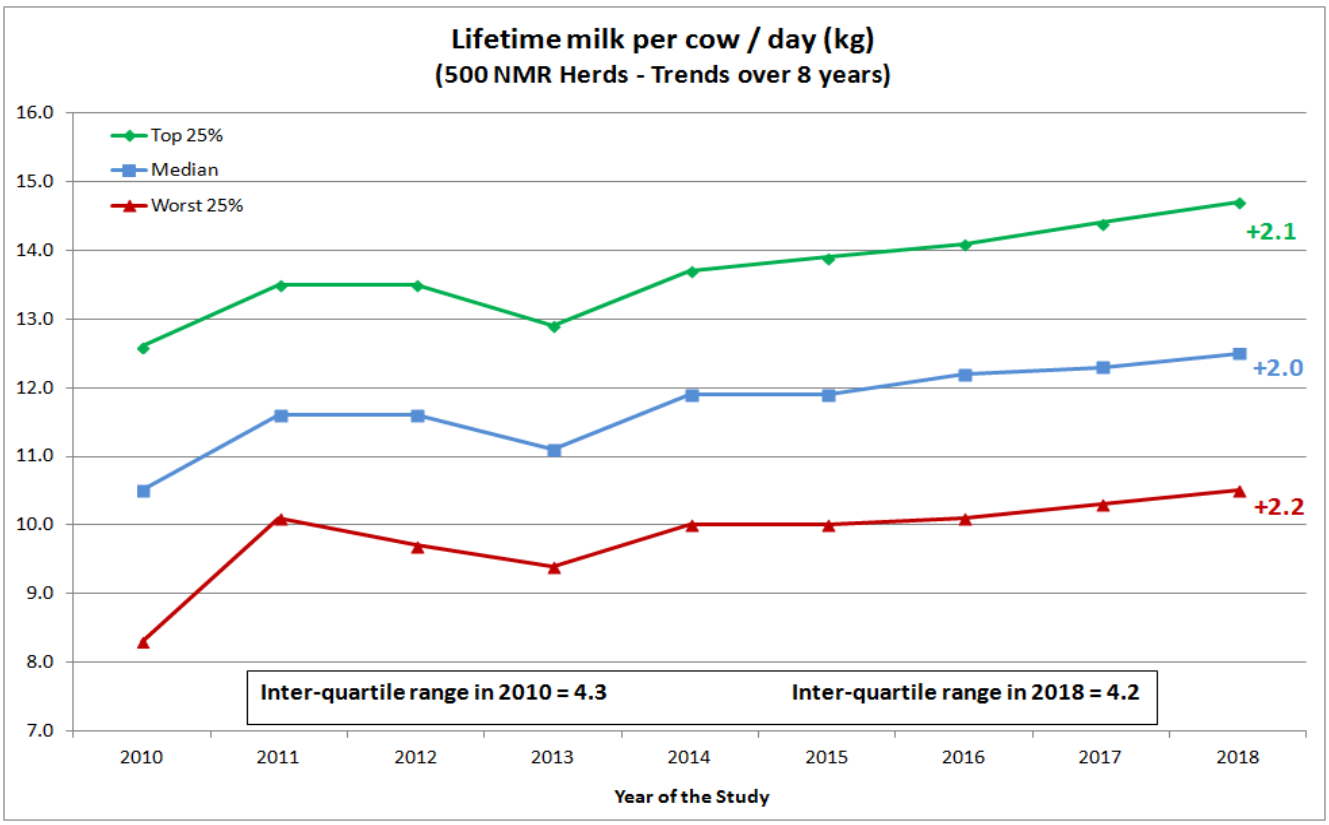
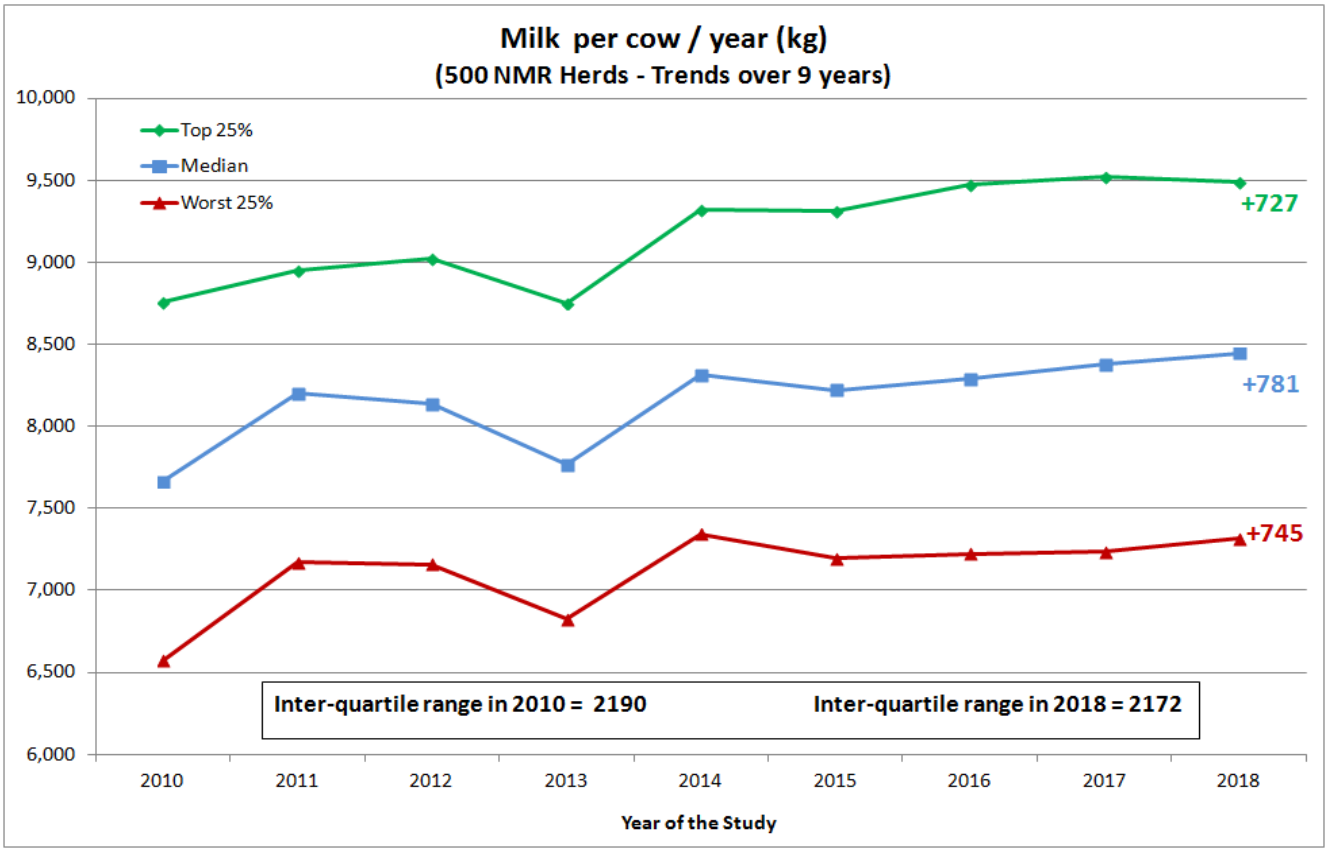


Figure 12. Milk per cow / year (kg)



3.4 Trends in Key SCC & Mastitis Parameters over the last 9 years

Figure 13. Herd Somatic cell Count

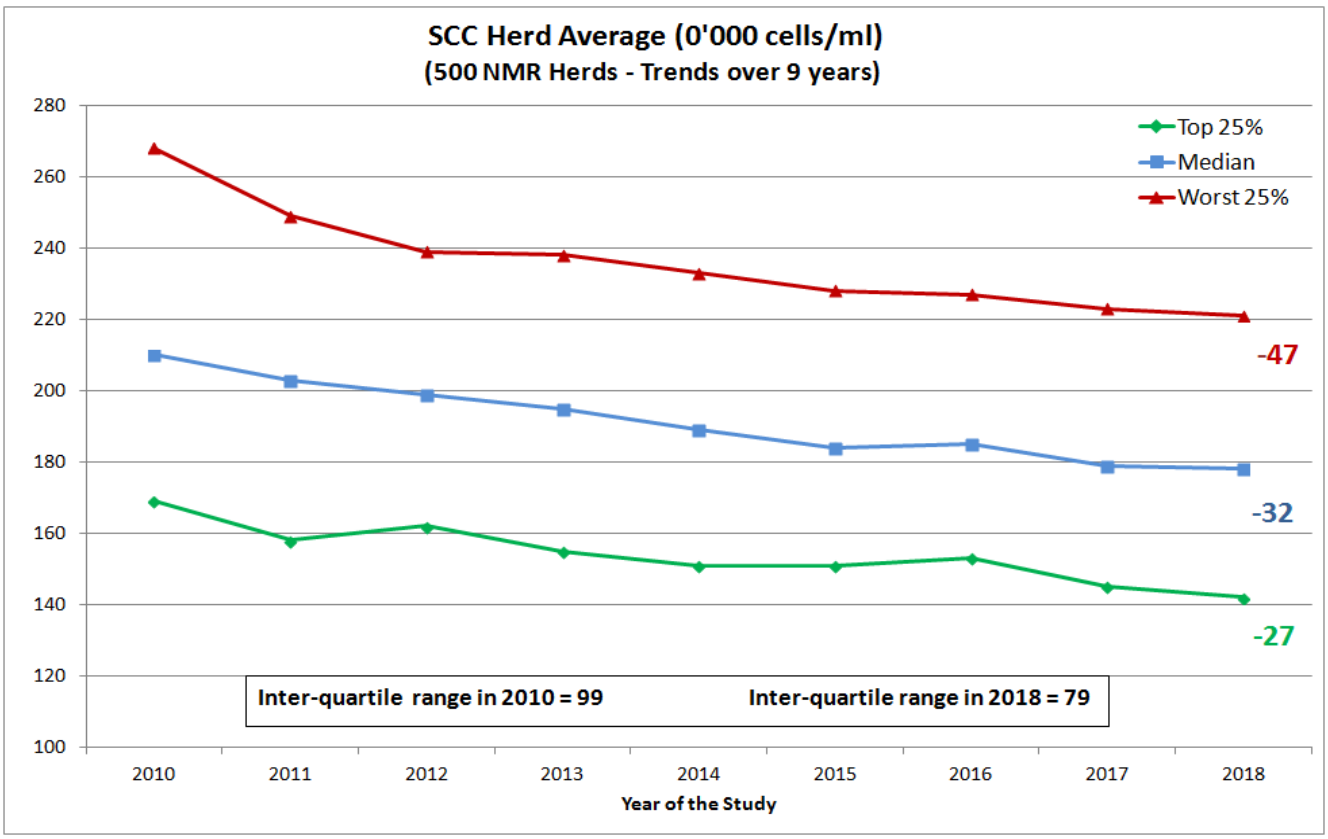


Figure 14. Percentage of milk samples originating from chronic (repeat) high SCC cows

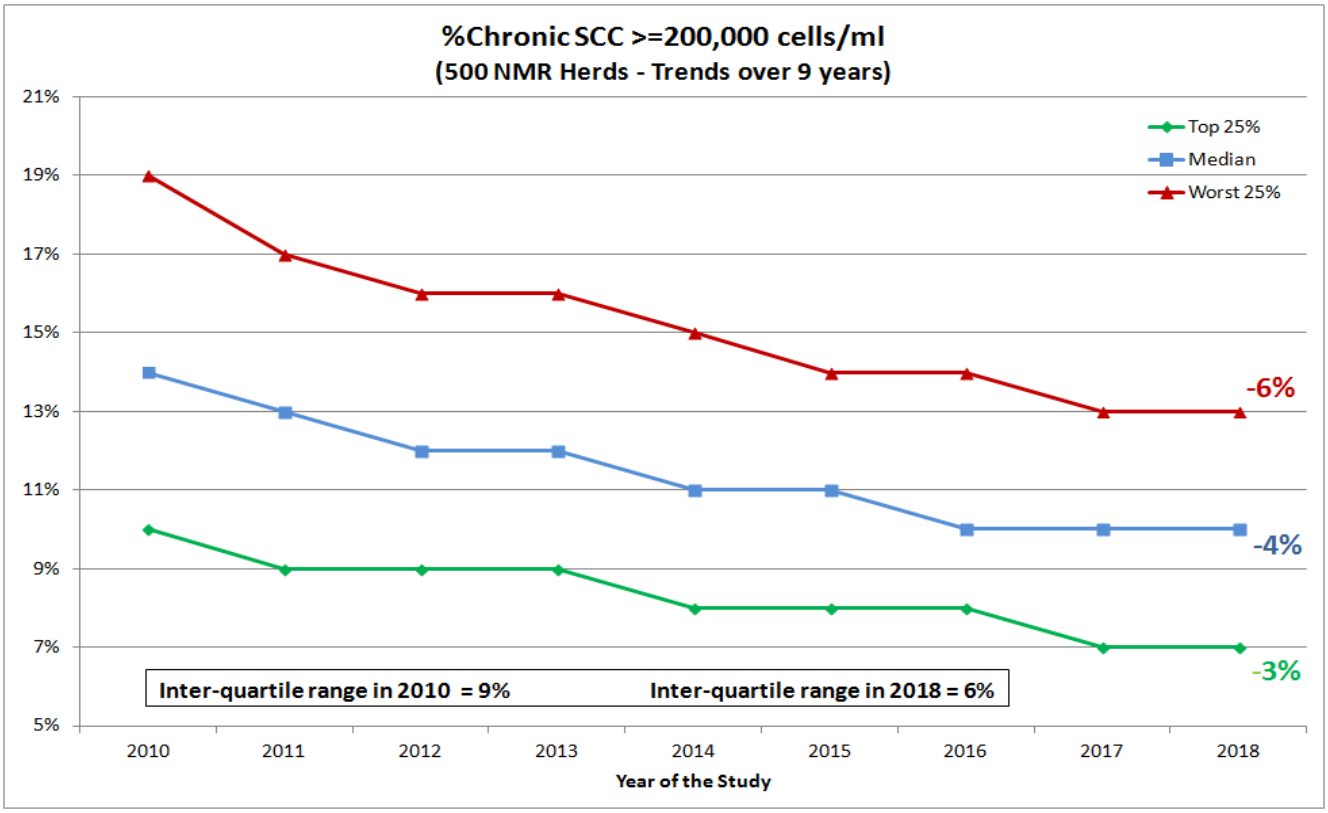
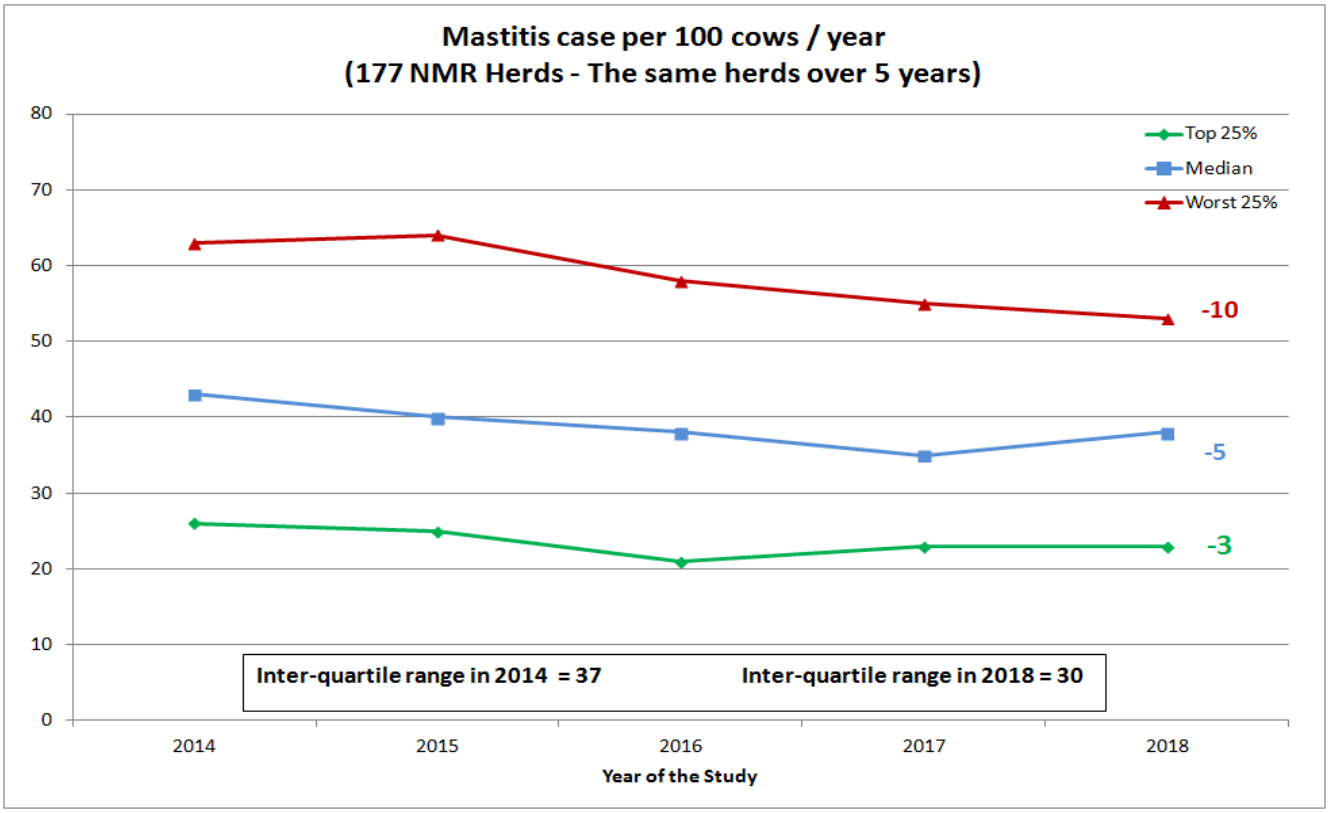


Figure 15. Mastitis rate (cases / 100 cows in milk / year)



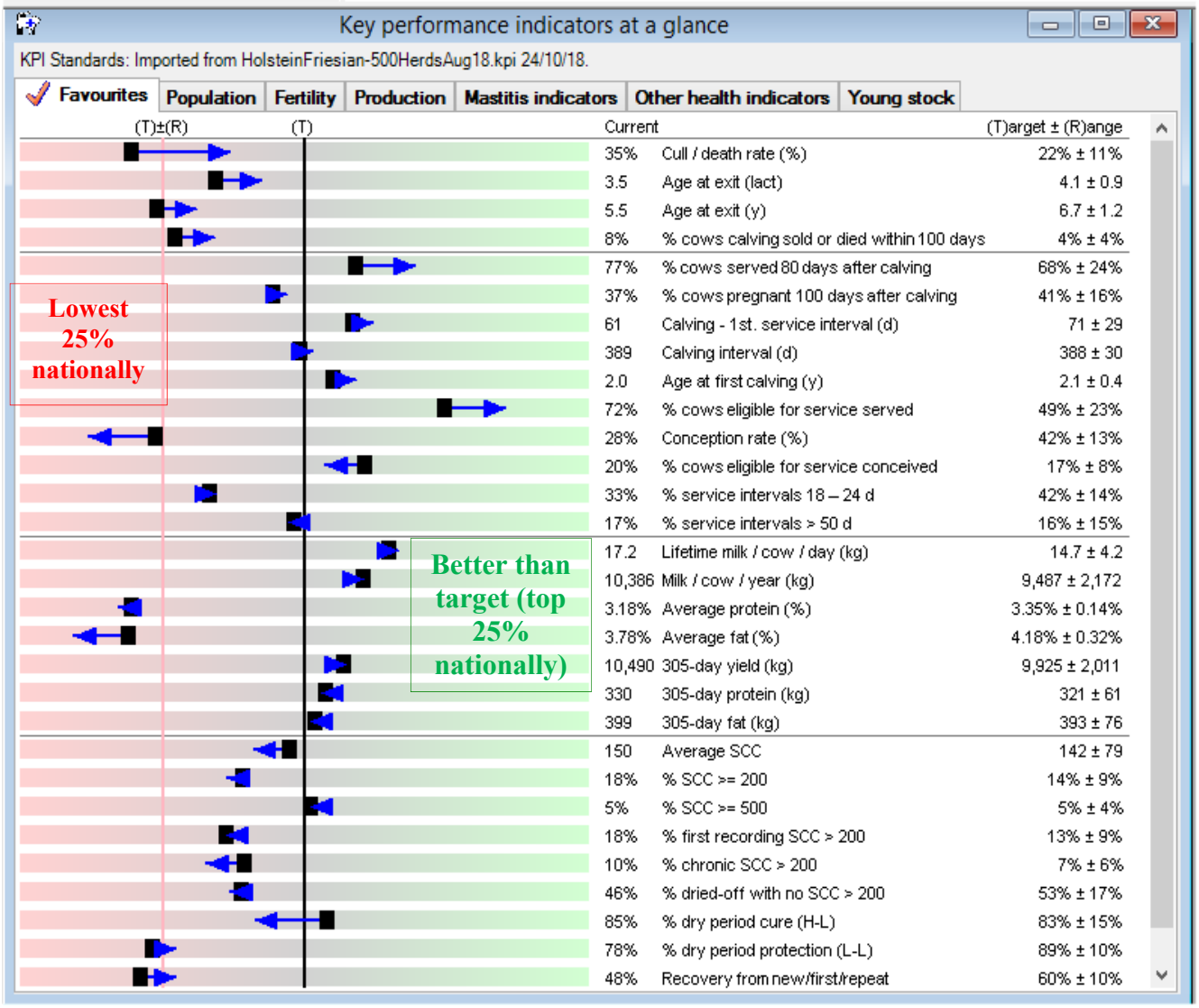
Section 4. The Practical Use of Key Performance Indicators By Farmers And Their Technical Advisers

The figures obtained from this study can be treated as “national standards” for UK 'black and white' dairy herds in 2018, with target values set at the level currently achieved on one in four of the 500 farms in the survey. A farmer can readily see where his/her herd would perform for each parameter relative to the 500 herds. This can be used to focus discussion on the causes and options/need for improvement.

The Key Performance Indicators Report in the InterHerd+ program provides an overview of performance for an individual herd. Parameters are calculated in an identical way so are directly comparable to the herds in the study. Comparing the performance of the herd with the results of the study highlights areas of strength and weakness in that herd’s performance (Figure 16).

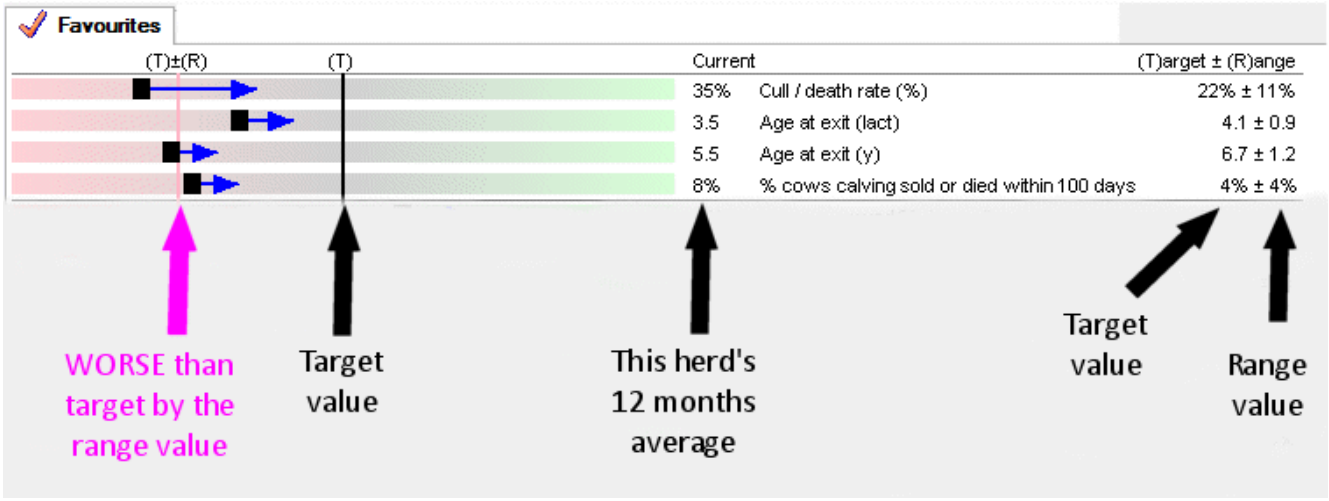
The combination of parameters relating to production, fertility and health, emphasizes the dynamic nature of dairy production and the need for high standards across all areas of herd management. Many herds are excellent in one area of production, fertility or health but seldom in all. There is always room for improvement in efficiency.

Figure 16. The Key Performance Indicator Report of InterHerd+



The meaning of the different lines and values against each key performance indicator are explained in Figure 17 below.

Figure 17. The KPI Report: The figures explained



The value displayed to the left of each parameter title represents the herd's performance over the last year. It is the rolling 12 month average for that parameter. In Figure 17 the herd had a cull/death rate averaging 35% over the previous 12 months.

To the right of each listed parameter is a **target** value and a **range** (corresponding to the values given in Tables 1(a) & 1(b). In Figure 17 above the TARGET value for cull/death rate is 22% with a range of ±11%.

These values are also displayed graphically to the left of the parameter titles. The **target** value is represented by the **vertical black** line. The area to the right hand side is shaded green to denote a performance level that is **better** than the target value.

Left of the target line is shaded **red** denoting performance that is **worse** than the target value. The **vertical red** line represents the level that is "**worse than the target by the range value**" (so the performance of the poorer performing 25% of herds). In Figure 17 for culling rate, the red vertical line represents the target (22%) worse by the range (11%) so a culling rate of 33%.

The positions of the black square and blue arrow  show how the current herd is performing for each parameter relative to the specified target and range values. The arrow indicates any direction of change.

- The **black square** is the **12 month rolling average** value for that parameter. So it is the longer-term performance based on the last 12 months of data (the value displayed to the left of the parameter title).
- The **blue** arrow head is the **3 months rolling average** value for that parameter. In other words it is the short-term performance based on the last 3 months only. The line and arrow show the difference and direction of change between the 3 and 12 month average values. Beware that while this may indicate a significant change in herd performance, the blue line may also be influenced by seasonal factors in that 3 month period.

Using the target and range values to highlight a herd's strengths & weaknesses

Herd strengths: This study identifies the level achieved by the best 25% of the herds for each parameter. That value is then set as the "TARGET" for comparison with other herds. In Figure 18, any KPI with a black square to the **right (green side) of the vertical black target line** is "**in the best 25%**" when compared to the 500 study herds. In Figure 18, the herd displayed has 12 parameters that are "better than target" so this herd would currently be in the top 25% of herds nationally for those parameters. This mainly includes several fertility & milk yield parameters.

Herd weaknesses: The **vertical red line** represents the performance achieved or bettered by 75% of the 500 herds (the target, worse by the range). Any parameter with a black square to the **left of the vertical red line** would be **"in the bottom 25%"** for that parameter when compared to the 500 study herds. There are 7 parameters highlighted in Figure 18, including culling, conception rate, protein & fat%, in addition to 2 SCC parameters, so this herd would currently appear in the bottom 25% of herds for those parameters.

Average performance levels: Parameters that fall between the vertical black and red lines are within the inter-quartile range (so the middle 50% of herds) when compared with the 500 study herds.

Figure 18. Highlighting the strengths and weaknesses of a dairy herd

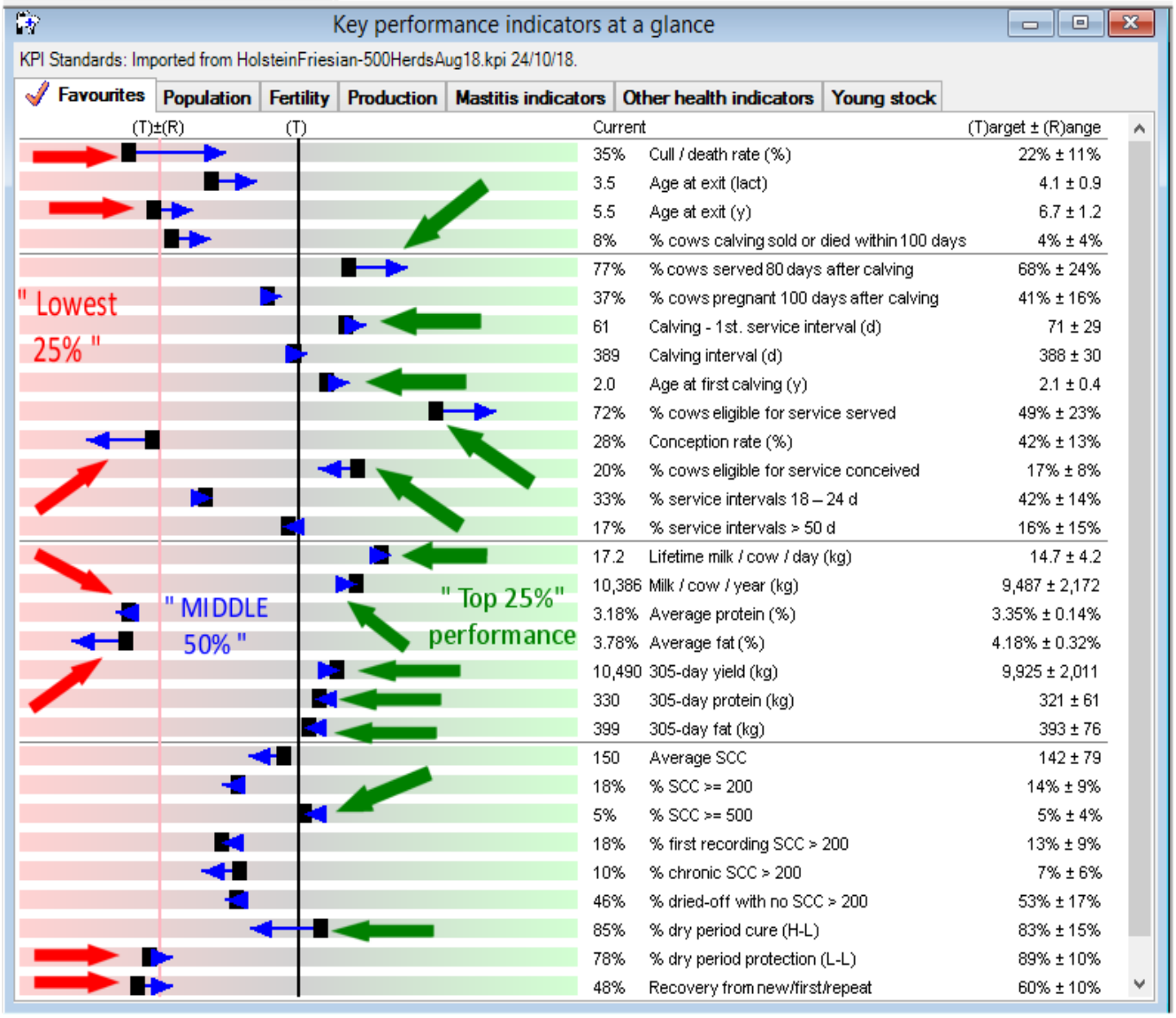


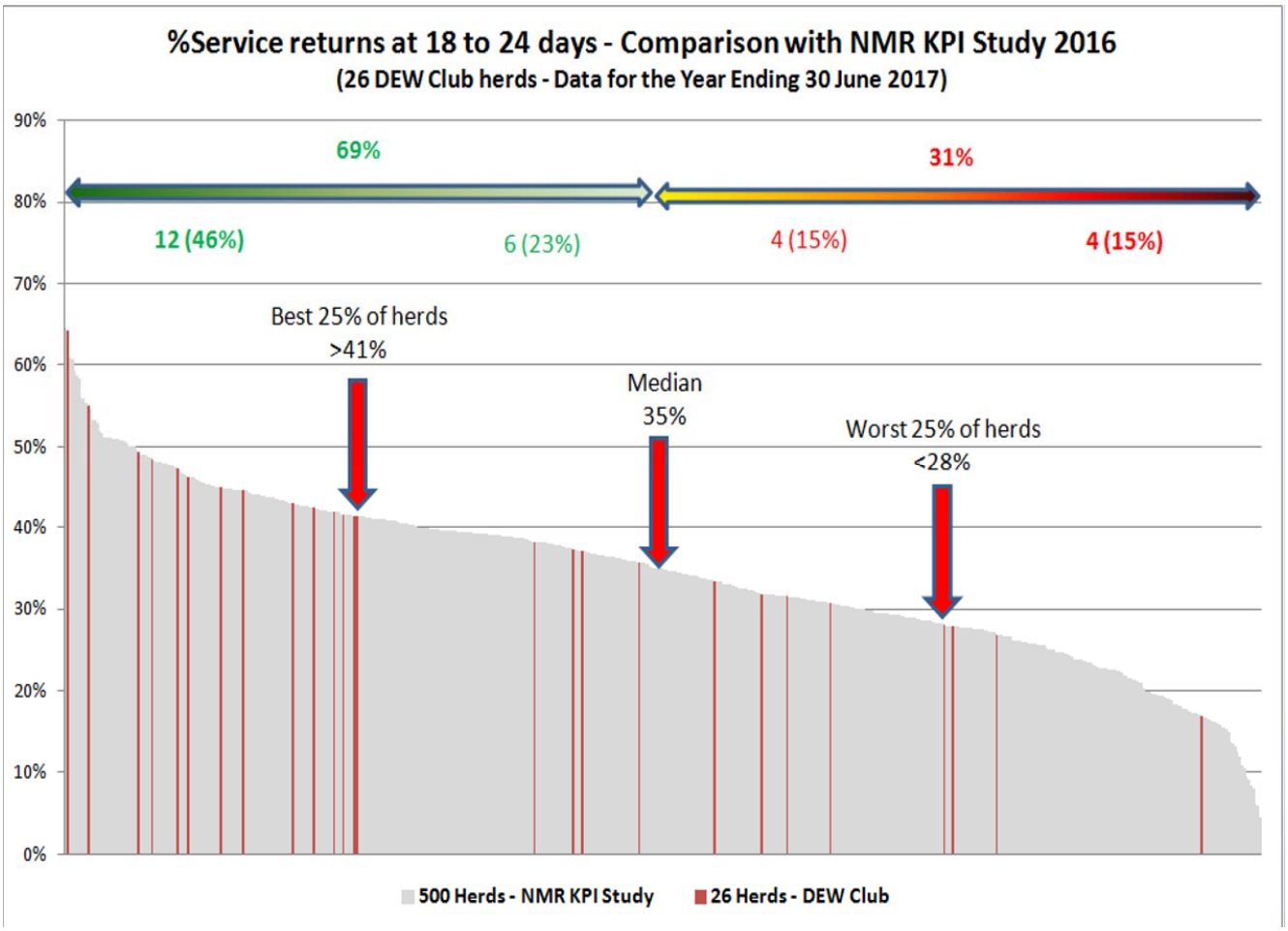
Figure 18 must be treated as a **DISCUSSION DOCUMENT**. The emphasis is on achieving an appropriate balance of performance in production, fertility and health. A parameter in the bottom 25% is not necessarily a bad thing, the herd in Figure 18, for example, has low protein% value for milk but as it is a high yielding herd the 305-day yield of protein would put the herd in the top 25%. Conversely, although in this herd most fertility parameters are in the "top 25%" performance, the conception rate is in the lowest 25%" performance level. The reason the conception is poor clearly needs investigation.

The aim is to **stimulate informed discussion between farmers and their advisers** about **what** is happening **and WHY.**

Monitoring performance and improvement of groups of herds

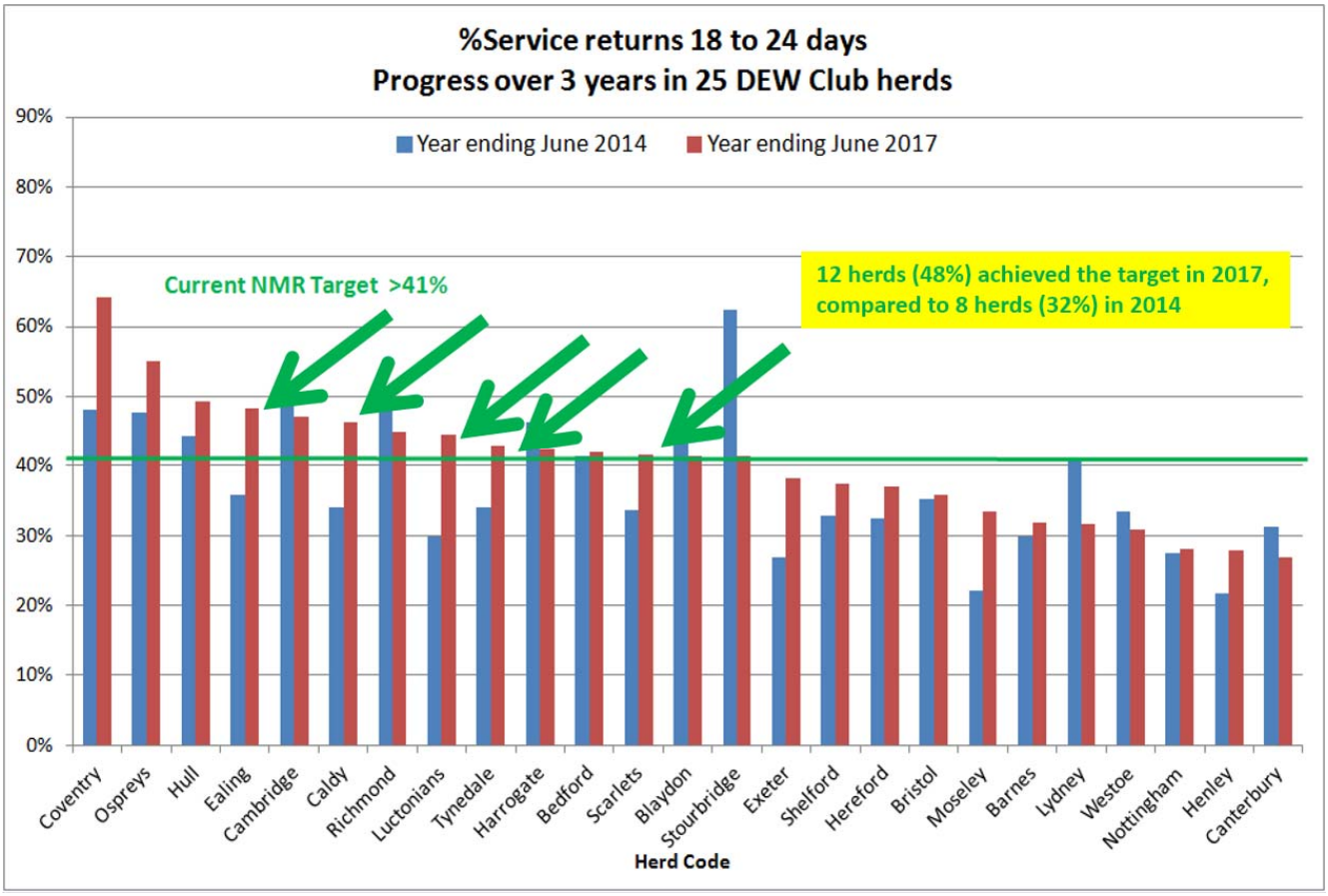
In addition to measuring individual herds, advisers and milk buyers are increasingly making use of the 500 herd graphs to monitor the status and improvement of their clients/members over time. Figure 19 shows the distribution of the heat detection rate of 26 client herds of Drove Farm Vets in Swindon, superimposed on the graph for the same parameter across the 500 herds. Each client herd is represented by a red vertical line. In this example it can be seen that 12 of the client herds are located in the best 25 % of herds in the 500 herd national study. So 12 of 26 herds (46% of the clients) have a performance level that puts them in the best quartile nationally.

Figure 19. Heat detection (of returns to service) of 26 client herds compared to the 500 herds study of 2016.



Comparing these results with the same herds (excluding one herd) 3 years earlier shows the significant progress the vet practice has made in improving heat detection (Figure 20). While there are still herds with poor heat detection, the proportion of the client herds in the top quartile has risen from 8/25 (32%) to 12/25 (48%). By comparing the performance level at the individual herd level, it is also easy to see which herds have made the most dramatic improvements. A number of the herds that are still outside the top quartile have still also made significant gains.

Figure 20. Changes over 3 years in Heat detection (of returns to service) for 25 client herds

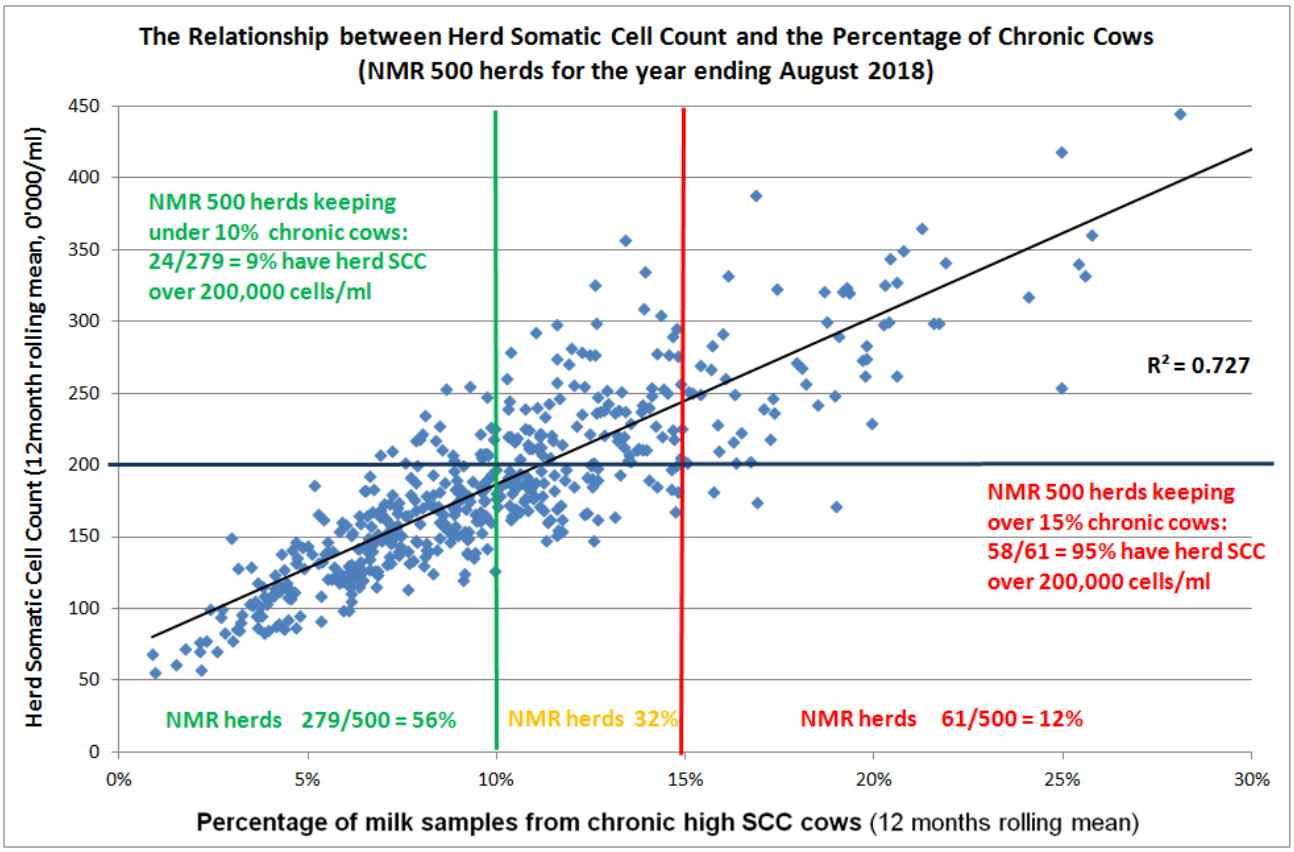


Relationship between parameters: Herd SCC vs % chronic high SCC milk samples

The 500 herd studies also provide data to investigate correlations between different Key Performance Indicators which can provide simple messages for farmers and advisers. A good example of this is the strong correlation between the Herd SCC and the percentage of milk samples deriving from chronic high SCC cows ($2^{nd}/3^{rd}/4^{th}$ etc consecutive high SCC milk sample). Figure 21 shows the distribution of the 500 herds from the current study (year ending 31st August 2018).

Each blue square represents one of the 500 study herds. The very strong correlation (r^2=0.727) is clearly evident giving a very clear message. If you have a high level of chronic cows in your herd you are also very likely to have a high herd SCC with all the costs and penalties associated with that.

Figure 21. The relationship between herd average SCC and the % chronic high SCC cows



In addition to the correlation the graph shows that in herds where over 15% of the milk is from chronic cows the vast majority are penalised for having a high herd SCC. In 2018 there were 61 herds of this type and 58 (95%) of them also had a high herd SCC (averaging greater than 200,000 cells/ml). In contrast, there were 279 herds with less than 10% chronic cows of which only 24 (9%) also had a high herd SCC.

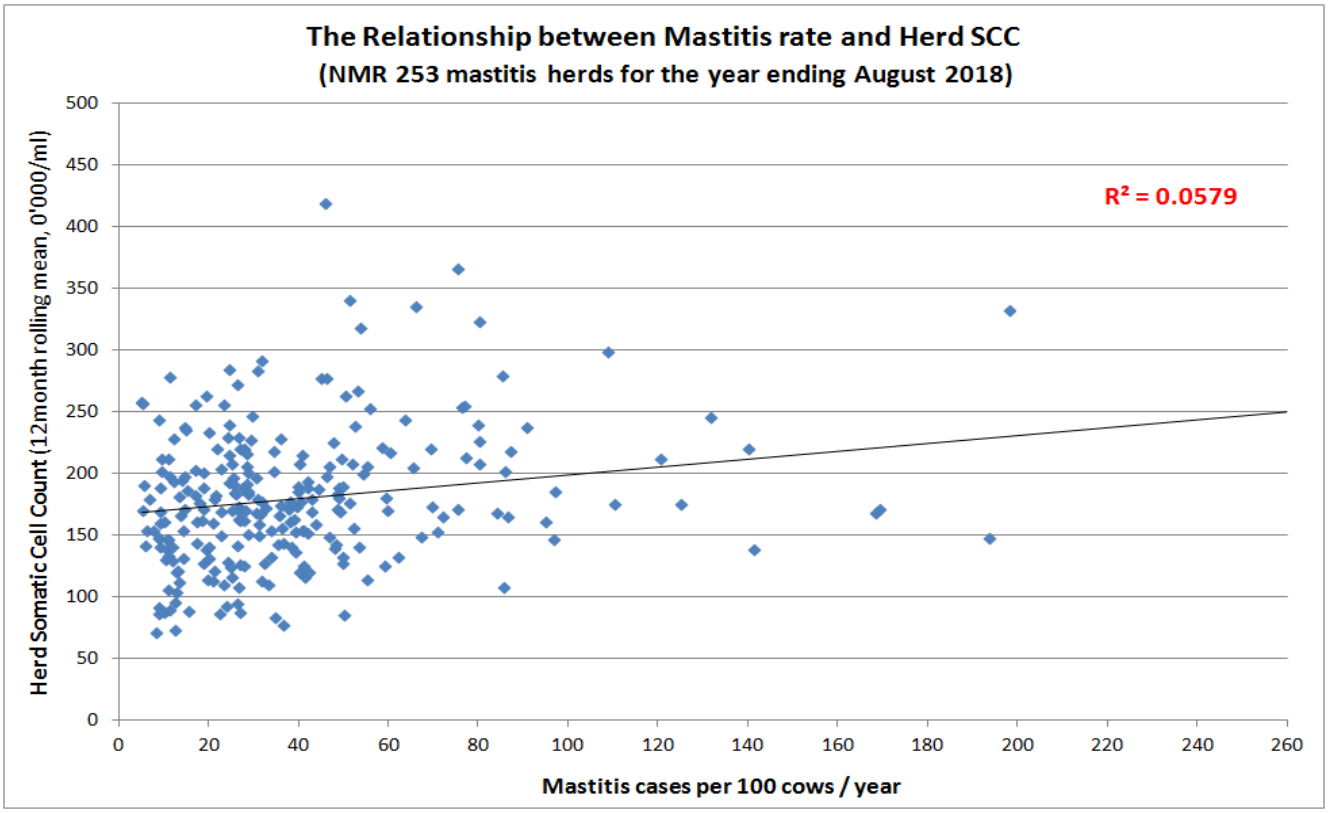
This strong correlation has been evident in all 9 annual KPI studies. Table 3 shows the enormous gains that the UK dairy industry has made in tackling high herd SCCs. The 56% of the herds (279/500) in the most recent study that qualify as “Low levels of chronic cows” (less than 10% chronic cows), are a dramatic improvement on the 24% of herds in the original study in 2010. Over the same time interval the % of herds keeping high levels of chronic cows (>=15% of the herd) has dropped from 41% of herds in 2010 to just 12% in 2018.

Table 3. Percentage of herds with low (<10%) and high (>=15%) levels of chronic high SCC samples, in the KPI studies from 2010 to 2018

KPI study year	Low levels of chronic cows (<10% of milking cows)	High levels of chronic cows (>=15% of milking cows)
2010	24% of herds	41% of herds
2011	32% of herds	35% of herds
2012	34% of herds	30% of herds
2013	36% of herds	29% of herds
2014	42% of herds	24% of herds
2015	44% of herds	21% of herds
2016	51% of herds	18% of herds
2017	51% of herds	17% of herds
2018	56% of herds	12% of herds

In contrast to the strong correlation between herd SCC and the level of chronic cows, there is no clear correlation between the level of mastitis incidence and the herd SCC. Figure 22 shows the poor correlation observed in 2018.

Figure 22. The relationship between herd average SCC and mastitis incidence



Appendix 1. Key Performance Indicators for Johne's Disease (JD) sero-prevalence.

The graphs below are derived from results for a group of 222 herds (within the "500 herds" in the current study) with regular quarterly JD testing for last 2 years. The precise criteria applied for herds to qualify for this sub-set were:

- The herd must have had more than 7 'all herd' milk JD tests, with the latest herd test being within the previous 6 months, and;
- All of the qualifying herd tests should have included at least 20% of cows present.

The 222 herds satisfied these criteria.

The milk ELISA carried out by National Milk Laboratories gives a continuous quantitative result (optical density: OD) based on a colour reaction. The quantitative result is interpreted and reported as either 'negative' or 'positive', with the OD 'cut-off' of <30 = 'negative' and ≥30 = 'positive'.

InterHerd plus (IH+) and NML/NMR have different schemes for categorisation of cows based on their individual JD test history.

InterHerd plus (IH+) uses three classes, and a 'no test' category:

- **NEG**… cow has been tested negative and has never had a positive test;
- **pNEG**… cow has had a positive result in the past (never two in a row), but most recent test was negative;
- **POS**… most recent test was positive, or has had two positives in a row (remain 'POS' for life);
- '**no test**' for untested cows or cows that were NEG but have not been tested for >12 months.

NML/NMR uses six 'J' categories, plus a 'no test' category and a 'lapsed' category:
Categorisation is based on up to the last four tests in the individual cow's history.

J0	**Repeat ELISA negative** – **minimum two tests** (within the 2 year qualifying window).	**NOT had a positive test among the most recent 4 tests / *or within 2 years of most recent test.***
J1	**ELISA negative** - **one test only** (within the 2 year qualifying window).	
J2	**Single ELISA positive followed by at least two negative** – 2 negative recent and consecutive tests negative, but with a **single** positive test in the previous 4 tests (within the 2 year qualifying window).	**Had a single positive test among the most recent 4 tests. NEVER had 2 x positive tests within a sequence of 4 tests.**
J3	**Single ELISA positive followed by one negative** – The last test negative and last-but-one positive. Also, if there are more tests, there can be only one positive in the recent 4 (within the 2 year qualifying window).	
J4	**First ELISA positive** – most recent test is the first positive test within a sequence of 4 tests.	
J5	**Repeat ELISA positive** - two or more positive results in any four consecutive tests at any time in individual cow test history. Once J5, J5 for life.	**Had 2 x positive tests within a sequence of 4 tests at any time in lifetime test history.**

In addition, '**no test**' is used for cows that have never been tested while '**lapsed**' is used for cows that were previously J0 or J1, but have not been tested for >12 months.

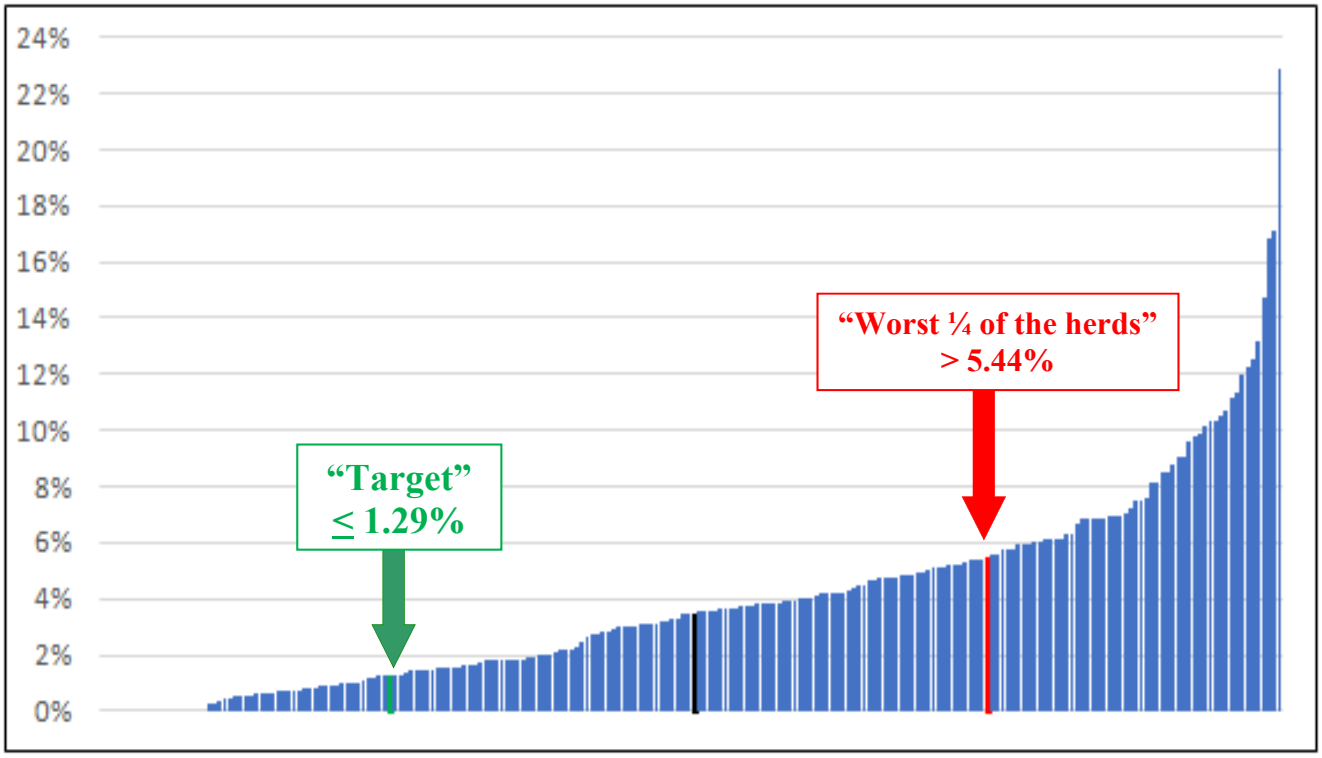
The following KPIs are based on the JD categorisation of cows present in the 222 herds on the 2nd October 2018. The KPIs calculated are:

- **Percent of cows in J5 category**… % of cows in the herd classed as J5 (NMR classification)
- **Percent of cows in J2, J3, J4, J5 category**… % of cows in the herd classed as J2, J3, J4, or J5 (i.e. cows that have had a positive test in the previous 4, or two positives within 4 tests any time in test history
- **Percent of POS or pNEG cows**… % of cows in the herd classed as POS or pNEG (IH+ classification)
- **Percent of POS cows**… % of cows in the herd classed as POS (IH+ classification)
- **Percent of cows with more than 2 Positive JD tests in lifetime**… % of cows in the herd that have more than 2 positive milk ELISA JD tests in their test history (over any time frame).

The charts below show the distribution of each parameter for the 222 herds (each bar is one herd). The data are sorted in ascending order (low is always 'better'). The green, black and red bars show (approximately) the positions of the best quartile, median, and the worst quartile respectively.

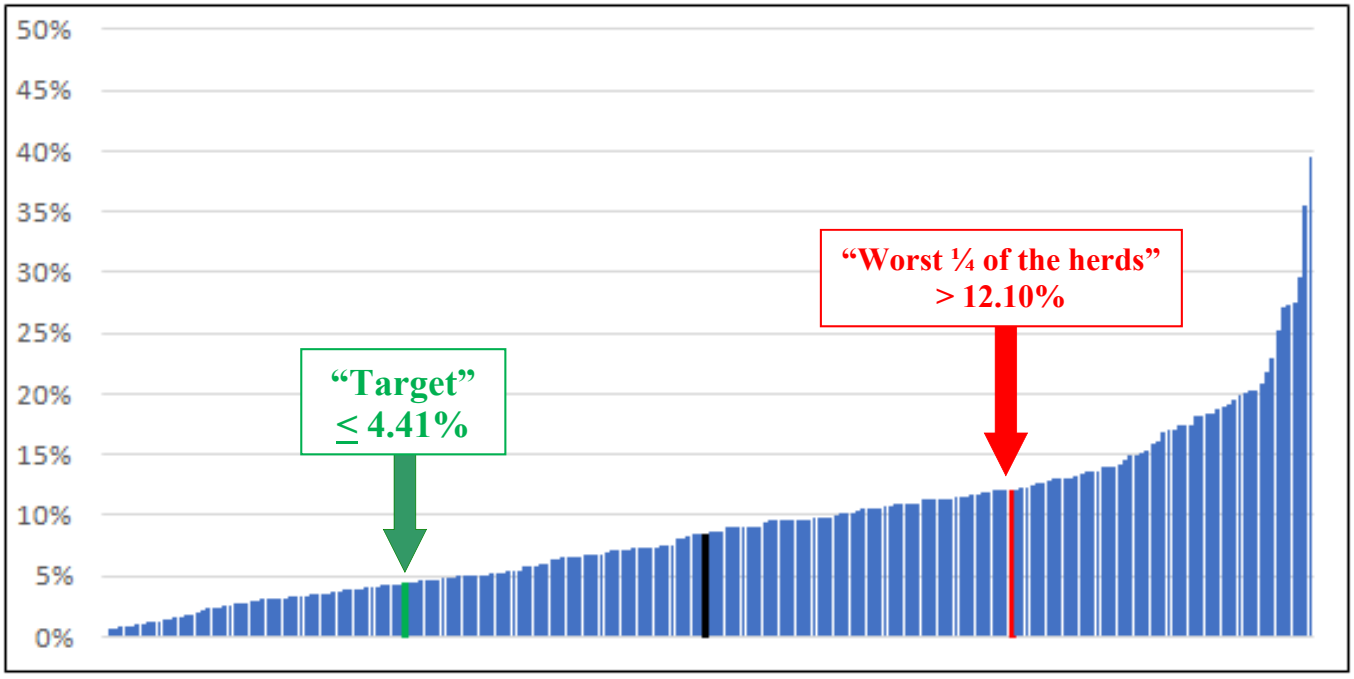
Percent of cows in J5 category in 222 NMR herds:

Target (top ¼ of herds' level):	**1.29%**
Median:	3.51%
75% level:	5.44%
Inter-quartile range:	4.15%



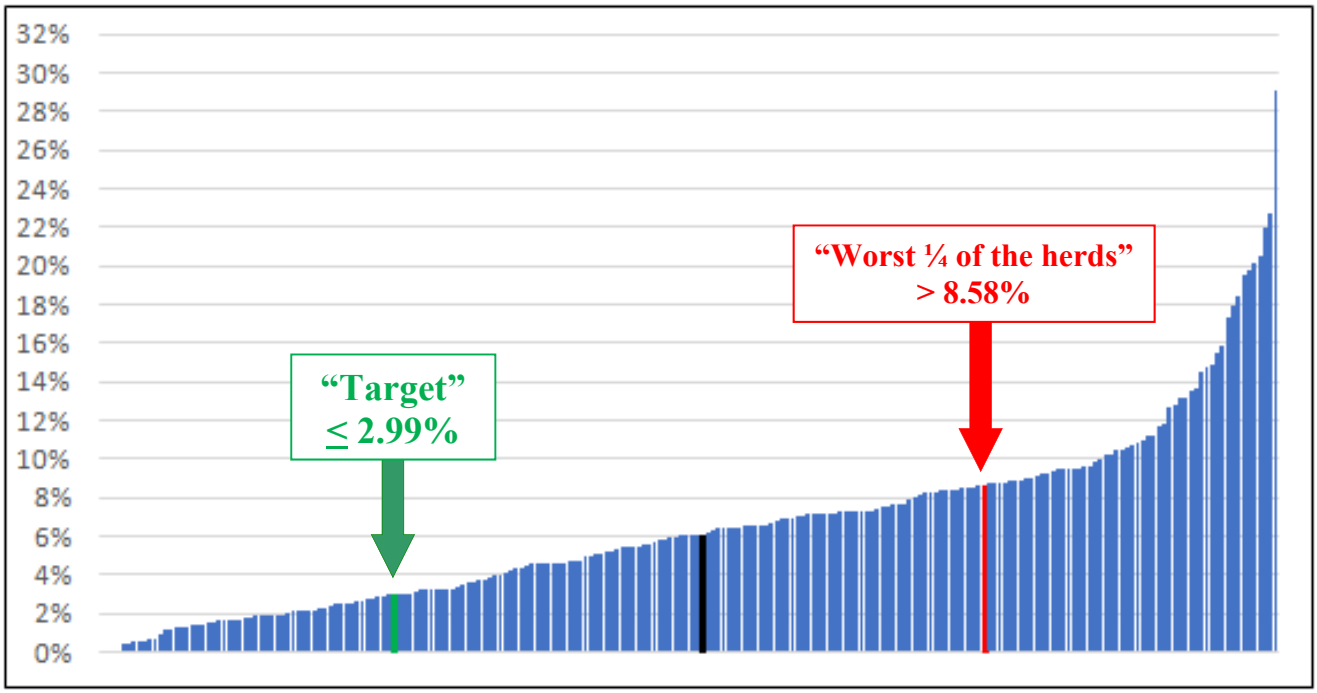
Percent of cows in J2, J3, J4, J5 category in 222 NMR herds:

Target (top ¼ of herds' level):	**4.41%**
Median:	8.56%
75% level:	12.10%
Inter-quartile range:	7.69%



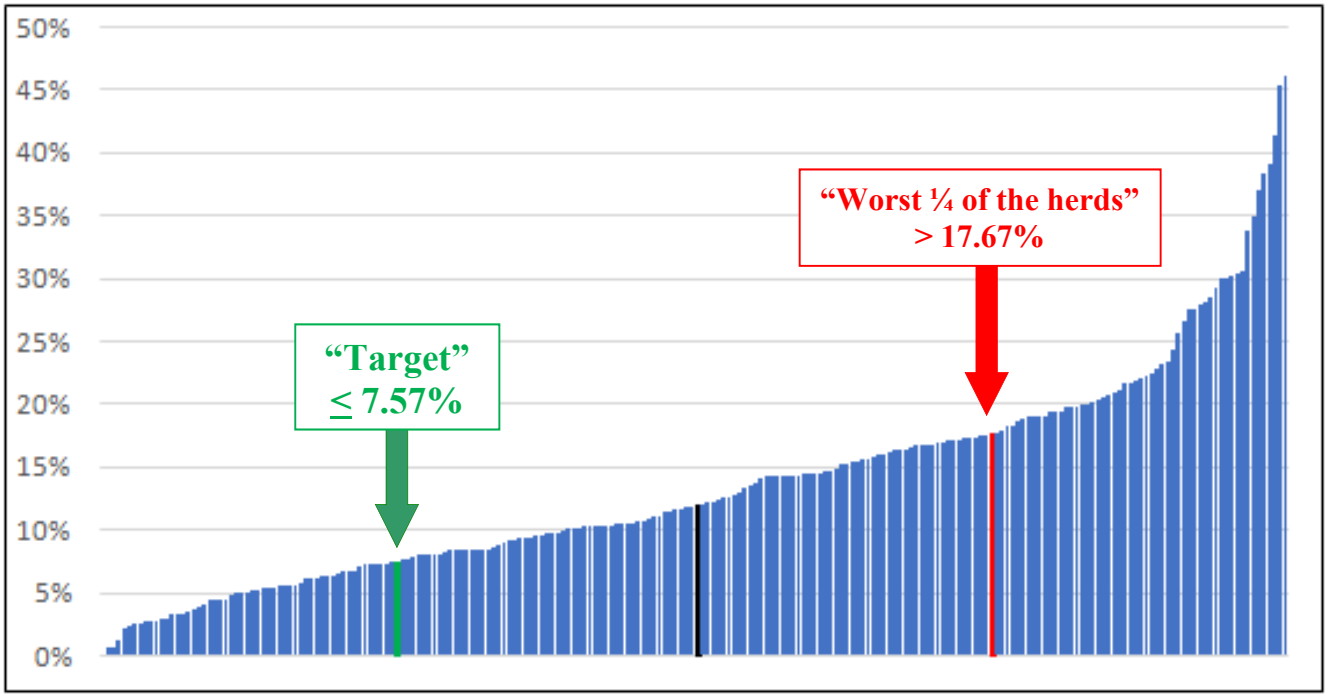
Percent of POS cows in 222 NMR herds:

Target (top ¼ of herds' level):	**2.99%**
Median:	6.10%
75% level:	8.58%
Inter-quartile range:	5.59%



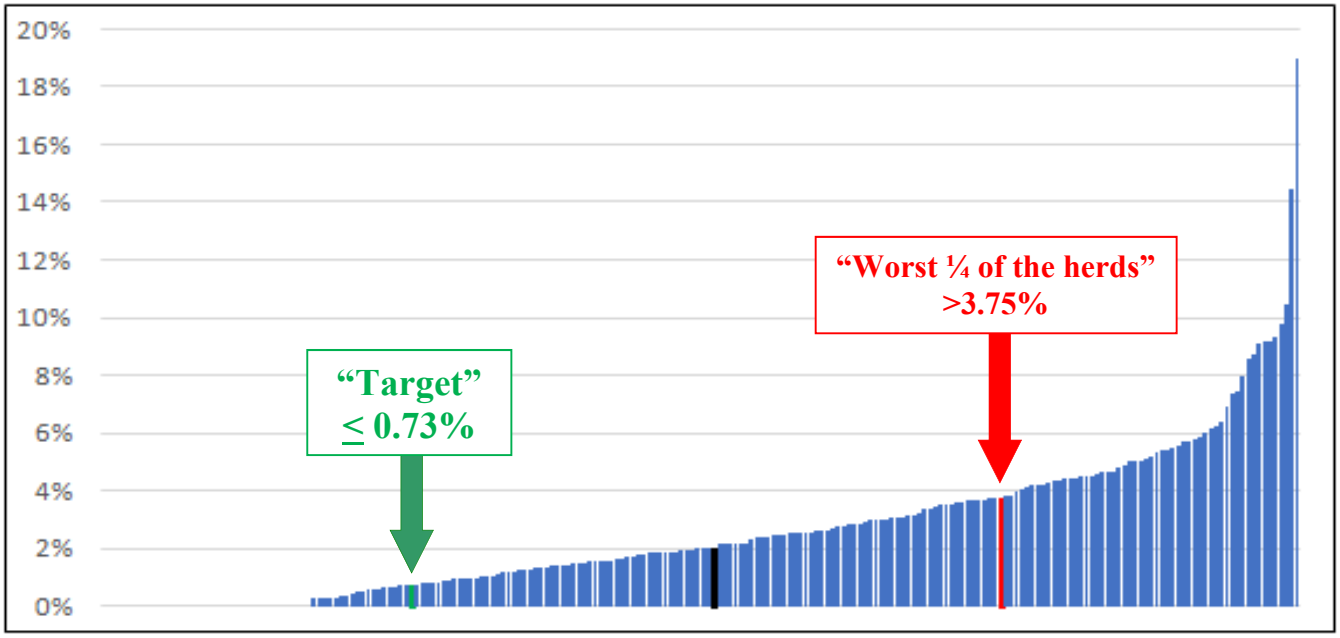
Percent of POS or pNEG cows in 222 NMR herds:

Target (top ¼ of herds' level):	**7.57%**
Median:	11.93%
75% level:	17.67%
Inter-quartile range:	10.10%



Percent of cows with more than 2 Positive JD tests in lifetime in 222 NMR herds:

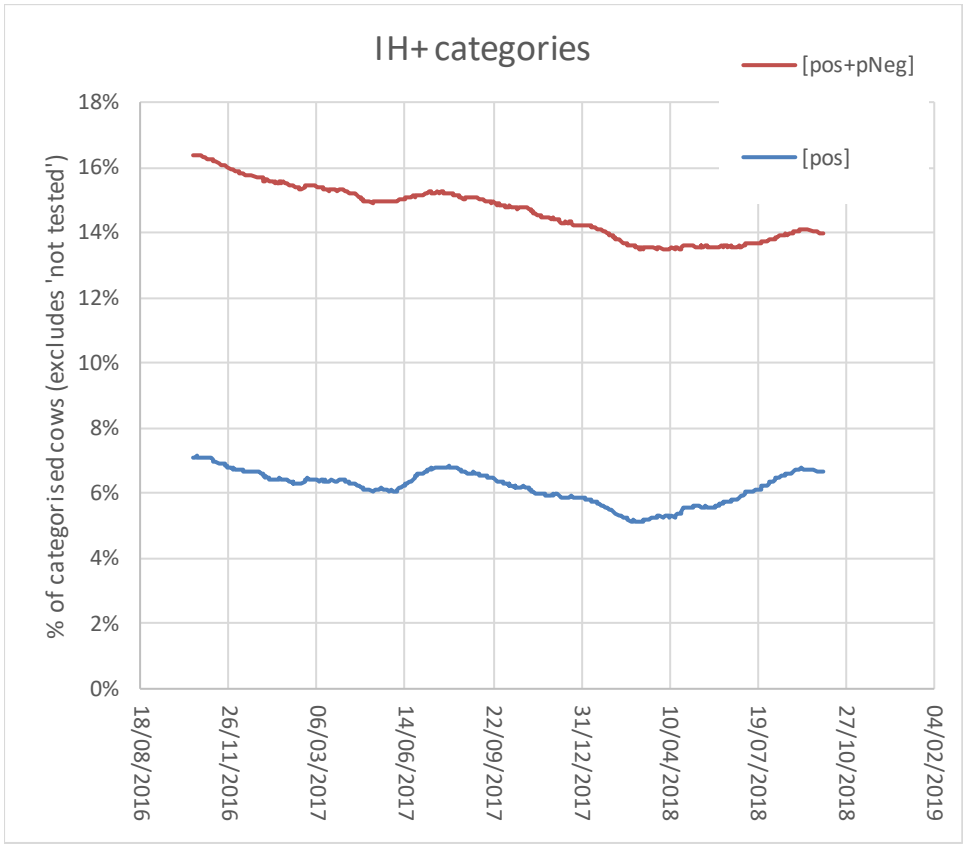
Target (top ¼ of herds' level):	**0.73%**
Median:	2.00%
75% level:	3.75%
Inter-quartile range:	3.02%



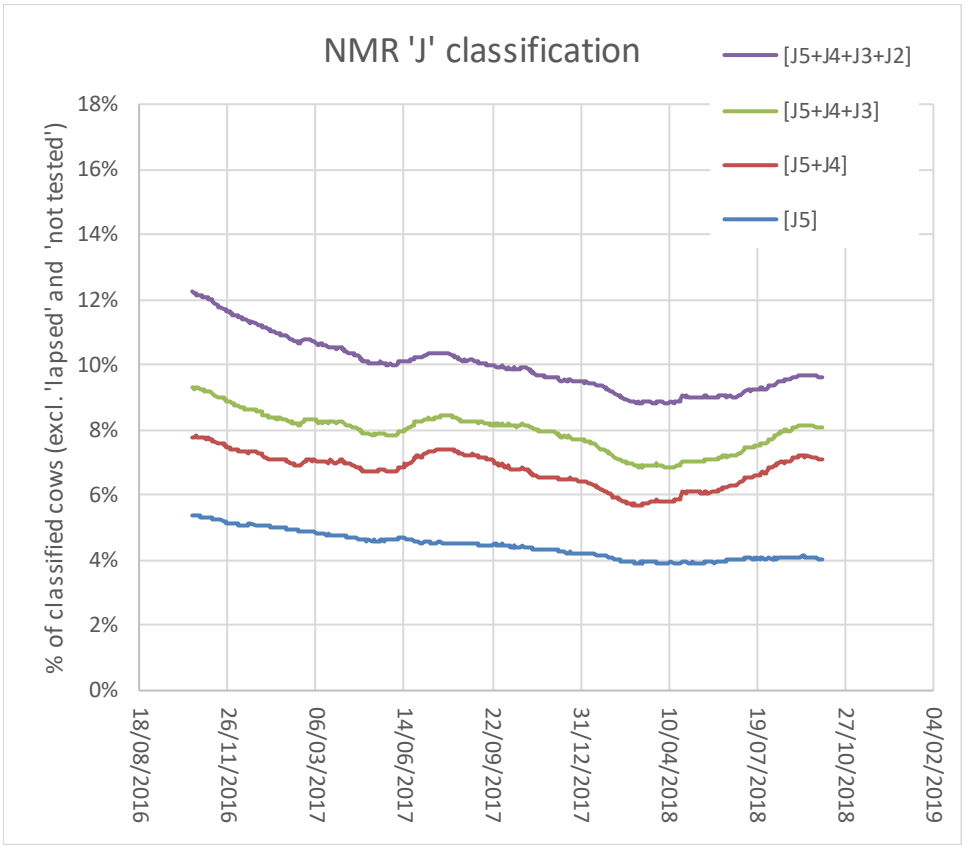
Trend over time (previous 2 years)

The following charts (A and B) show the percentages of all categorised cows in the 222 herds (analysed as one group) that were in the various sero-positive categories.

A) InterHerd+ JD categories



B) NMR JD classification



IH+ 'pos' category broadly includes NMR classes J5 (cows had 2 pos in any 4 tests – J5 for life) and J4 (first time positive at most recent test)… so those two lines have the same shape… but the 'pos' line in the left (IH+) chart is lower than the brown (J5+J4) line on the right (NMR) chart because to be 'pos' for life in IH+ requires 2x consecutive positive but to be J5 for life in NMR requires 2x positive in any 4 tests) – so some of the NMR J5s will be pNeg in the IH+ categorisation. In the NMR system cows with positive tests can revert to J0 (equivalent to 'neg') if they have a run of more than 4 negative tests… in IH+ these cows remain pNeg for life… therefore the brown (pos+pNeg) line on the left (IH+) chart is higher than the top line (J5+J4+J3+J2) on the right (NMR) chart.

One feature worthy of further investigation is the apparent increase in the J4 category (single recent test positive) over the previous six months.

Appendix 2. Key Performance Indicators definitions

In the following definitions the average population of cows is calculated using animal days. Every day that animal is present in the population at risk during the period of study is a 365th of an animal year. The total animal days is divided by 365 to give animal years, which equates to the average population at risk.

Parameter	Description
A. Culling rate	The number of cows dying or culled during the 12 month period expressed as a percentage of the average cow population for the same 12 month period.
B. Percentage culled / died 100 days after calving	The percentage of heifers/cows calving during the 12 month period that exit within 100 days after calving.
C. Age at exit (years)	The average age (in days) of cows culled/died in the analysis period, divided by 365.24
D. Age at exit by lactations	The average number of lactations completed by cows culled/died in the analysis period.
E. Percentage Served by day 80	The percentage of cows reaching the 80th day after calving that have been served at least once.
F. Percentage conceived 100 days after calving	The percentage of cows reaching 100 days after calving that have conceived.
G. Calving to 1st service interval (days)	The average days between calving and 1st service for all cows served for the first time in a lactation during the analysis period.
H. Calving interval (days)	The interval between calvings, in days, for all re-calvings recorded in the analysis period.
I. Age at 1st calving (years)	The age at first calving for all cows calving for the first time during the analysis period.
J. Conception rate	The number of conceptions as a percentage of the total number of services (services to cows culled are included) during the analysis period.
K. Percentage service intervals at 18-24 days (Heat detection)	The percentage of all service intervals for cows returning to service during the analysis period that are between 18 and 24 days (equating to one oestrus cycle after the previous service).
L. Percentage service intervals >50 days	The percentage of all service intervals for cows returning to service during the analysis period that are over 50 days.
M. Percentage of cows eligible for service that were served (Submission rate)	The percentage of cows that are eligible for service (42 days+ after calving and not barren or already pregnant) during the analysis period that are served per 21 day (oestrus cycle) period.
N. Percentage of cows eligible for service that conceived (Pregnancy rate)	The percentage of cows that are eligible for service (42 days+ after calving and not barren or already pregnant) during the analysis period that conceive per 21 day (oestrus cycle) period.
O. Lifetime milk / cow/day (kg)	The total milk produced per cow and heifer place in the year. The total milk produced in the year, divided by the average population of cows (both in milk and dry) and heifers (including heifer replacements being reared elsewhere), divided by 365.
P. Milk / cow / year (kg)	The total milk produced per cow place in the year. The total milk divided by the average population of cows (both in milk and dry).
Q. Average protein%	The weighted average protein% of all milk recorded during the analysis period.

Parameter	Description
R. Average fat%	The weighted average fat% of all milk recorded during the analysis period.
S. 305 day yield (kg)	The average 305 day production for all cows reaching 305 days after calving during the analysis period.
T. 305 day protein (kg)	The average 305 day production of milk protein for all cows reaching 305 days after calving during the analysis period.
U. 305 day fat (kg)	The average 305 day production of milk fat for all cows reaching 305 days after calving during the analysis period.
V. Average SCC ('000 cells/ml)	The weighted average somatic cell count of all milk recorded during the analysis period.
W. Percentage SCC >=200,000 cells/ml	The percentage of all recorded milk samples during the analysis period that had an individual SCC reading of 200,000 cells/ml or higher.
X. Percentage SCC >=500,000 cells/ml	The percentage of all recorded milk samples during the analysis period that had an individual SCC reading of 500,000 cells/ml or higher.
Y. Percentage 1st recording SCC >=200,000 cells/ml	The percentage of all cows starting new lactations that had a high SCC (>=200,000 cells/ml) reading at the first milk recording in the lactation.
Z. Percentage chronic SCC >=200,000 cells/ml	The percentage of all milk samples taken in the analysis period that originated from chronic SCC cows where the current and previous milk samples both had SCC levels of 200,000 cells/ml milk or greater.
ZA. Percentage Dry period cure (High:Low)	Of re-calving cows recorded starting a new lactation during the analysis period: the percentage of cows ending the previous lactation with a HIGH SCC (>=200,000 cells/ml) that started the new lactation with a LOW SCC (<200,000 cells/ml).
ZB. Percentage Dry period protection (Low:Low)	Of re-calving cows recorded starting a new lactation during the analysis period: the percentage of cows ending the previous lactation with a LOW SCC (<200,000 cells/ml) that also started the new lactation with a LOW SCC (<200,000 cells/ml).
ZC. Percentage Low at end of previous lactation (SCC<200,000 cells/ml)	Of re-calving cows recorded starting a new lactation during the analysis period: The percentage that had a LOW SCC (<200,000 cells/ml) at the last milk recording in the previous lactation.
ZD. Percentage New SCC >=200,000 cells/ml	The percentage of all recorded milk samples that were of the "New" SCC Category, namely the first HIGH SCC (>=200,000) in a lactation following one or more low SCC samples.
ZE. Percentage Dried-off with no SCC >=200,000 cells/ml	The percentage of cows completing a lactation without recording a high SCC (cows recording only LOW SCC samples (<200,000 cells/ml) in the previous lactation).
ZF. Threshold Index new high / new low	Of cows with consecutive milk records in the same lactation, the number of cows changing from Low SCC at the previous to High SCC at the next recording divided by the number of cows going from High SCC at the previous to Low SCC at the next recording.
ZG. Recovery percentage of new/first/repeat infections	Of HIGH SCC cows (>=200,000cells/ml) that at the previous recording were either low SCC or not yet in milk, the percentage that were LOW SCC (<200,000 cells/ml) at the following recording.

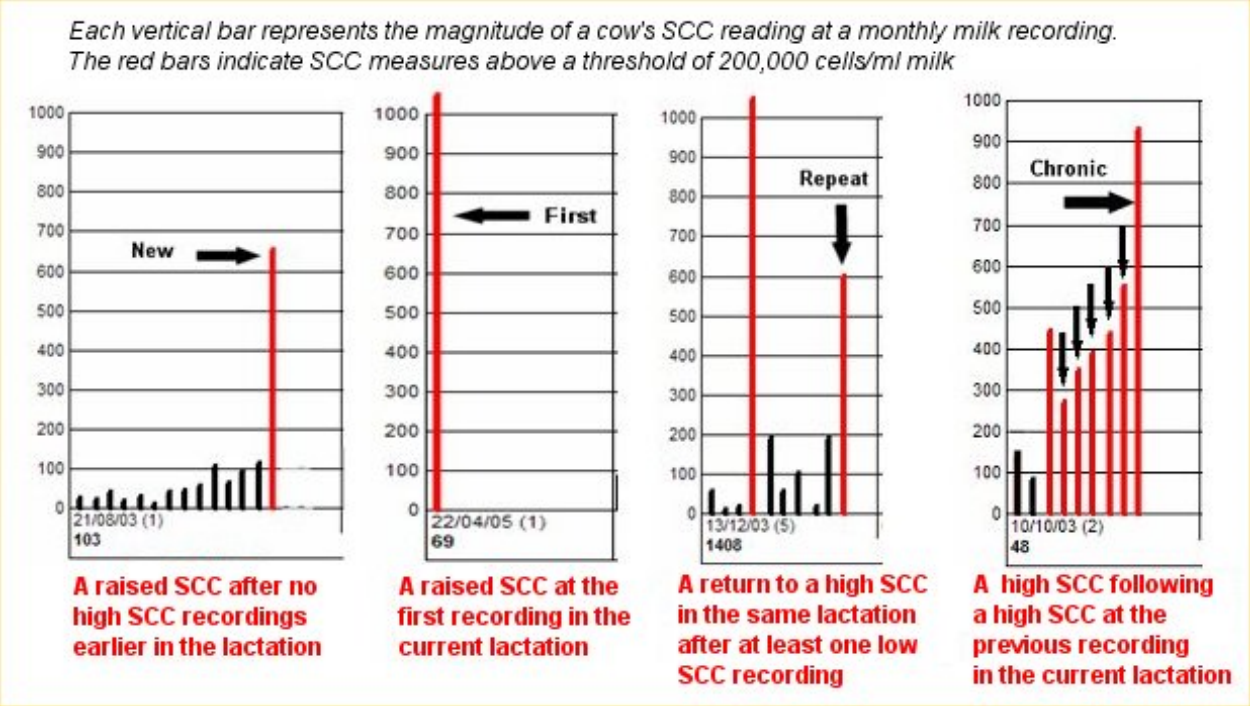
Parameter	Description
ZH. Recovery percentage of chronic infections	Of CHRONIC High SCC cows (High SCC cows that at the previous recording were also High SCC), the percentage of those milked that were LOW SCC (<200,000 cells/ml) at the following recording.
ZI. Percentage drying off with no mastitis cases	The percentage of cows completing a lactation without recording a mastitis case.
ZJ. Mastitis rate (cases/100 cows in milk per year)	The total cow cases of mastitis recorded divided by the average population of cows in milk, represented as a % (cases/100 cows in milk).
ZK. Index mastitis case by Day 30	The percentage of cows calving during the12 month period that recorded a mastitis case by day 30 of the lactation.
ZL. Index mastitis rate after Day 30	The incidence rate of ***index*** mastitis cases in cows that have passed 30 days since calving.

Appendix 3. Herd Companion High SCC Categories

The web-based Herd Companion program (**www.nmr.co.uk/Herd-companion**) was introduced by NMR in 2003 primarily to support the use of milk recording data to control somatic cell counts (SCC) in dairy herds.

Herd Companion focuses more on the duration of a high SCC infection rather than the magnitude of an individual milk sample. Using a threshold of 200,000 cells/ml milk to indicate infection, the program aims to balance the ability of many cows to self-cure with the need to assist cows where infection is becoming established. While in the region of 50% of cows self-cure after an initial raised SCC this recovery rate falls to less than 20% once a cow has recorded a second high SCC. It is these persistent high SCC cows that require attention before they are damaged irretrievably by a sustained period of infection.

The development of Herd Companion led to the definition of four main categories of high cell count cow, as illustrated below. Each vertical bar represents the magnitude of the SCC at each milk recording in a lactation. Where the bar is black the SCC is below the threshold of 200,000 cells/ml milk. A red bar indicates a SCC level above the threshold.



NEW: The "New" category describes cows recording their first high SCC in the lactation, having recorded one or more low SCCs at earlier recording(s). An infection acquired in the lactation.
FIRST: The "First" category describes cows that are HIGH SCC at their First milk recording in the current lactation. This is an infection that may be related to the dry period.
REPEAT: The "Repeat" category describes a possible re-infection (or failure to cure). A cow that had high SCC recording(s) earlier in the current lactation recorded a LOW SCC in the previous month(s) but has returned to a High SCC at the latest recording.
Chronic: The "Chronic" category describes a cow that is High SCC at the latest recording AND was also High SCC at the PREVIOUS recording(s). So she was high SCC last time and failed to recover. In the example above the cow has 7 consecutive high SCC recordings so has been defined as Chronic for the last 6 months of consecutive high SCC recordings.