Long lasting cows

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Executive Summary
Longevity is a complex trait influenced by a large number of environmental and genetic factors. A question that has arisen during the NBO review is: What characteristics help cows to survive a long time, such as 10 years of age? To assess the outcome of selecting on several predictor traits we analysed data on cows that had up to 8 survival records i.e. survive to eight or more lactations, using the records of about 2 million Holstein cows and 300,000 Jersey cows born from 1990 to 2003. Trends over time in ADHIS evaluated traits were calculated for cows that have 1, 2-5 and 6+ survival records. When cows have 6+ survival records, there are many type and production traits that are significantly different to cows with only one survival record (i.e. likely to be culled in 1st lactation). For production, SCC and fertility, the difference between groups can be large, whereas for many type traits the difference was smaller, but still significantly different. There is also evidence that culling patterns for many traits have remained the same over the last decade, as differences between the means of groups of cows with 1 versus 6+ records has been fairly consistent over the years studied. An even better way of analysing these data is by fitting all the traits simultaneously, as this reveals the effect of the trait tested that is independent of everything else, there were 23 that had a statistically significant association with survival in Holsteins and 10 for Jerseys. However, by just including type/workability traits, there is only a small reduction in the variance explained by using the best 5 predictors for Holsteins (udder depth, likability, BCS, pin set and overall type) and for Jerseys the best model is likability, mammary and overall type. Thus, we have confirmed that the prediction model for survival in Holsteins is correct. The Jersey dataset is smaller and therefore there is more noise in it, although the best model was slightly different to Holsteins, further work is required to ascertain whether the difference is large enough to warrant a different prediction model.

Introduction
Longevity is a complex trait influenced by a large number of environmental and genetic factors. It is difficult to improve genetically because it has a low heritability and it is not fully known until a cow is culled or dies. Currently the survival ABV of a bull is based on actual survival of his daughters and on ABVs for udder depth, pin set, overall type and likability. From time to time it is important to check if these predictors of survival work as expected. To assess the outcome of selecting on several predictor traits we analysed cows that had up to 8 survival records i.e. survive up to eight lactations using the records of about 2 million Holstein cows and 300,000 Jersey cows born from 1990 to 2003.

Data were trait deviations (TDs) and daughter trait deviations (DTDs) obtained from ADHIS for Holsteins and Jerseys. Data were available on 35 traits that are currently evaluated by ADHIS. TDs were calculated from raw phenotype data by fitting a model which includes herd-year-season, age of cow and permanent environment effect. Daughter trait deviations for bulls were then calculated from the trait deviations of their daughters after correcting for the genetic merit of their mate (Haile-Mariam et al., 2014). Therefore, the survival TD and DTD does not include any type predictors. Two subsets of data were created, one was Holsteins born from 1990 and the other was Jerseys born from 1990.

A question that has arisen during the NBO review is: What characteristics help cows to survive a long time, such as to 10 years of age? The ADHIS TD file includes the number of effective records for survival, which ranges between 1 and 8, where 1 is one survival record and 8 is 8 or more survival records. This approximates the lactation number when the cow was culled. Although the number of survival records is unlikely to properly differentiate between management practices, it may be a useful way to approximate the relationship between survival and predictor traits in a way that can be used for extension purposes. For this analysis, the number of survival records grouped into: 1 record only; 2-5 records and 6+ records.

Cows that have 6+ survival records have higher scores for overall type and are higher yielding. The difference in milk yield between the groups with 1 and 6+ records is 247 litres (Holstein) and 249 litres (Jersey) and for overall type the corresponding differences are 0.31 (Holstein) and 0.68 (Jersey), the t-test applied to these differences was highly significant $p<0.001$ (Figures 1 and 2). The difference in linear type assessment score for udder depth between cows with 6+ and 1 survival records was on

average +0.11 in Holsteins (Figure 3), i.e. the cows that survived longer had shallower udders that were different statistically, yet the dimension of this effect is relatively small. The other point to note is that the difference between groups remains fairly consistent over years, especially for traits such as yield, fertility, SCC etc. This implies that culling rates for these traits is probably the same now as it was 10 years ago.

An even better way to assess the value of a trait to predict survival is to use an analysis known as multiple regression. The way this analysis works is to estimate the effect of a trait independent of all other traits fitted in the model. Therefore, the value of say overall type can be assessed after accounting for production, fertility, SCC and all other type traits. Year of birth was the also fitted as a fixed effect to avoid genetic trend bias. The statistical significance (p-values) were calculated so that they were conditional on other traits included in the model, i.e. the p-value of the explanatory variable after correcting for all other explanatory variables (Table 1).

Table 1. P-values and regression estimates (b) from multiple regression analysis of survival on ADHIS TDs in Holsteins and Jerseys, cells highlighted in yellow are significant at P<0.001.

	Holsteins			Jerseys		
	P-value	b	Error	P-value	b	Error
Angul	2.60E-15	-0.0064	0.0008	5.27E-01	-0.002	0.003
BCS	4.21E-14	0.0146	0.0019	5.54E-01	-0.004	0.007
BodyD	2.25E-22	-0.0082	0.0008	7.04E-04	-0.009	0.003
BodyL	7.64E-01	0.0004	0.0014	6.24E-01	-0.001	0.003
Bone	5.78E-01	-0.0004	0.0008	2.19E-01	-0.004	0.003
CentL	4.75E-01	0.0006	0.0008	2.33E-01	0.003	0.002
ChestW	8.96E-03	0.0023	0.0009	2.13E-01	0.003	0.003
Fat	<1.0E-99	0.0012	0.0000	<1.0E-99	0.002	0.000
Fert	<1.0E-99	-0.0003	0.0000	<1.0E-99	-0.001	0.000
FootA	2.37E-01	-0.0010	0.0008	1.00E+00	0.000	0.003
ForeA	4.03E-03	0.0023	0.0008	1.29E-03	0.007	0.002
Like	<1.0E-99	-0.0398	0.0006	<1.0E-99	-0.058	0.002
Loin	1.74E-04	-0.0038	0.0010	7.52E-01	0.001	0.003
Mamm	2.53E-04	0.0034	0.0009	5.54E-02	0.003	0.001
Milk	<1.0E-99	0.0001	0.0000	1.04E-95	0.000	0.000
MuzW	3.26E-09	-0.0047	0.0008	6.63E-01	-0.001	0.003
OType	2.75E-91	0.0195	0.0010	2.19E-09	0.009	0.001
PinSet	9.50E-27	0.0063	0.0006	3.43E-01	0.002	0.002
PinW	3.99E-11	-0.0045	0.0007	7.64E-01	-0.001	0.002
Prot	<1.0E-99	0.0015	0.0000	4.76E-76	0.002	0.000
RearAH	6.77E-08	-0.0042	0.0008	1.28E-01	-0.004	0.002
RearAW	3.23E-16	-0.0063	0.0008	2.77E-01	-0.003	0.003
RLeg	8.41E-01	-0.0002	0.0008	8.88E-01	-0.001	0.005
RSet	5.32E-01	0.0005	0.0008	4.62E-01	-0.002	0.003
RumpL	2.01E-02	0.0032	0.0014	7.91E-01	-0.001	0.003
Scc	<1.0E-99	-0.0003	0.0000	9.47E-21	0.000	0.000
Stat	8.26E-13	-0.0048	0.0007	2.26E-02	-0.005	0.002
TeatL	8.06E-01	-0.0001	0.0005	8.62E-01	0.000	0.002
TeatPF	2.75E-01	-0.0007	0.0007	4.98E-01	0.001	0.002
TeatPR	9.96E-06	-0.0043	0.0010	1.24E-01	-0.005	0.004
Temp	9.44E-07	-0.0033	0.0007	2.49E-01	-0.002	0.002
UdDep	1.61E-108	0.0168	0.0008	3.67E-28	0.025	0.002
UdTex	1.67E-11	-0.0055	0.0008	4.98E-01	-0.002	0.003

For example:
In Holsteins, the 'b' value for fat is 0.0012 meaning it has a positive relationship with survival. It is highlighted yellow, meaning the P-value indicates it is a significant relationship.

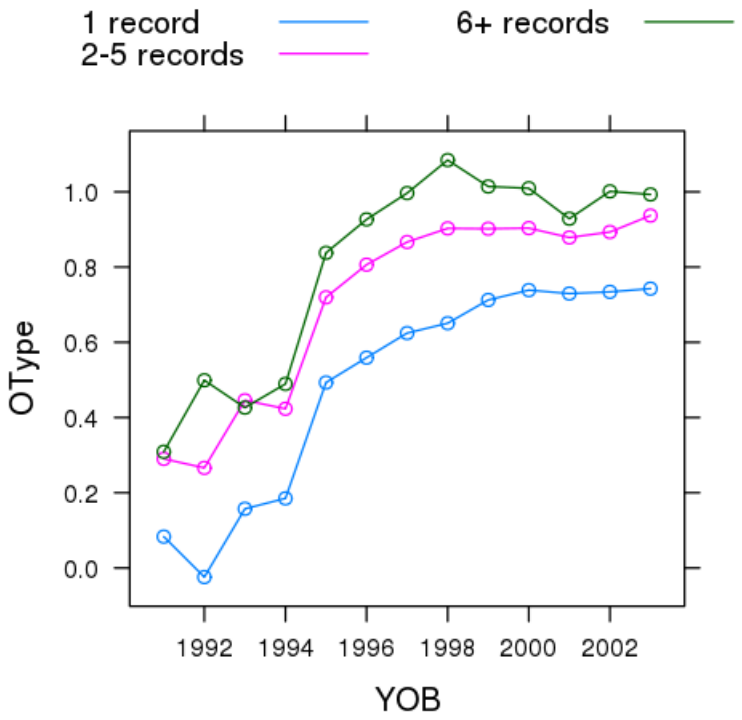
Note: 'Fert' = Calving Interval
A negative value for 'b' is desirable. Cows with better survival have lower (smaller) calving interval.

When all TDs were fitted simultaneously to the survival TD, there were 23 that were significant for Holsteins and 10 for Jerseys (Table 1). The dataset for Jerseys was smaller, which could be one reason why fewer associations were significant for Jerseys. For most traits, the direction of effect matches expectation, however, there are a number of notable cases where the direction differs, for example in the analysis of cows with 1 versus 6+ survival records, wider pins (positive effect on PinW) was associated with greater survival ($P<0.01$) see Figure 6, while in the multiple regression shown in Table 1, the effect of PinW on survival was negative ($P<0.001$). In fact, most of the traits associated with size and dimension had a negative effect on survival in the multiple regression analysis. At this point we cannot offer a satisfactory explanation for this observation, but it could be because other aspects of size are already corrected for by other traits in the model, so the remaining part, that can be explained by PinW has an unexpected effect.

The next step was to investigate what the best predictors of survival were, i.e. if we lose anything from reducing the number of predictors. In fact, there was only a small reduction in the variation explained by successively dropping the least significant effects until only the best predictors remained. In Holsteins, the best prediction model for survival is still likability, overall type, udder depth and pin set, i.e. the same model as ADHIS currently use, BCS is also a useful predictor. The best prediction of survival in Jerseys included the following traits: likability, mammary system and overall type.

Figure 1. The trend of trait deviation for overall type against year of birth (YOB) for survival categories: cows with 1 survival record, 2-5 survival records and 6+ survival records

a) Holsteins



b) Jerseys

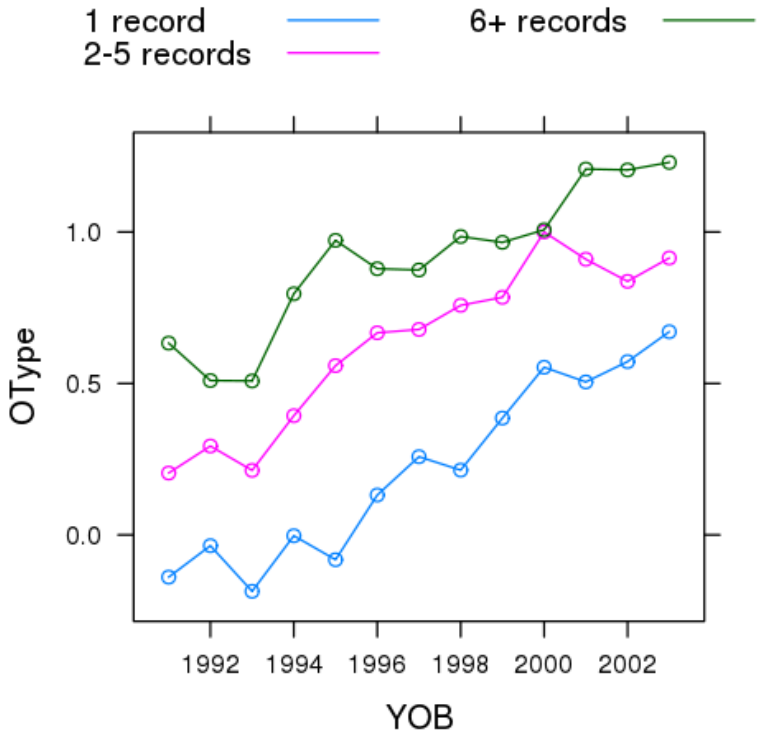
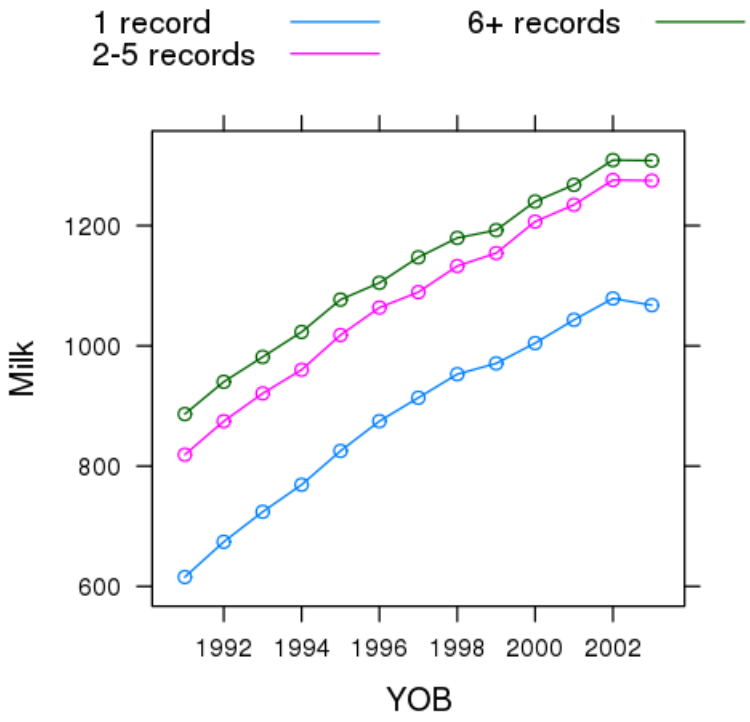


Figure 2. The trend of trait deviation for milk yield (litres) by year of birth (YOB) for survival categories: cows with 1 survival record, 2-5 survival records and 6+ survival records

a) Holstein



b) Jersey

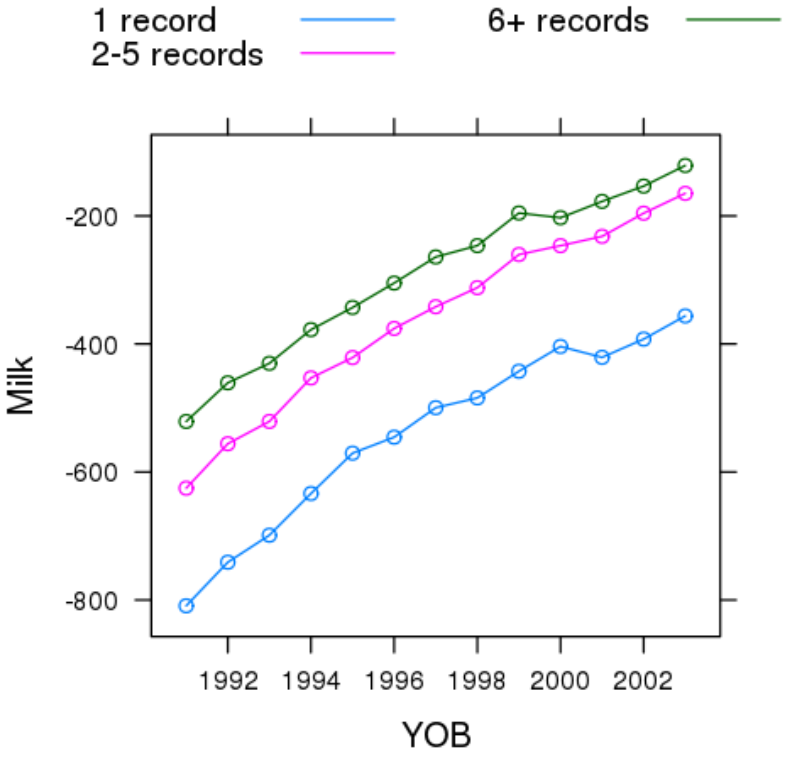
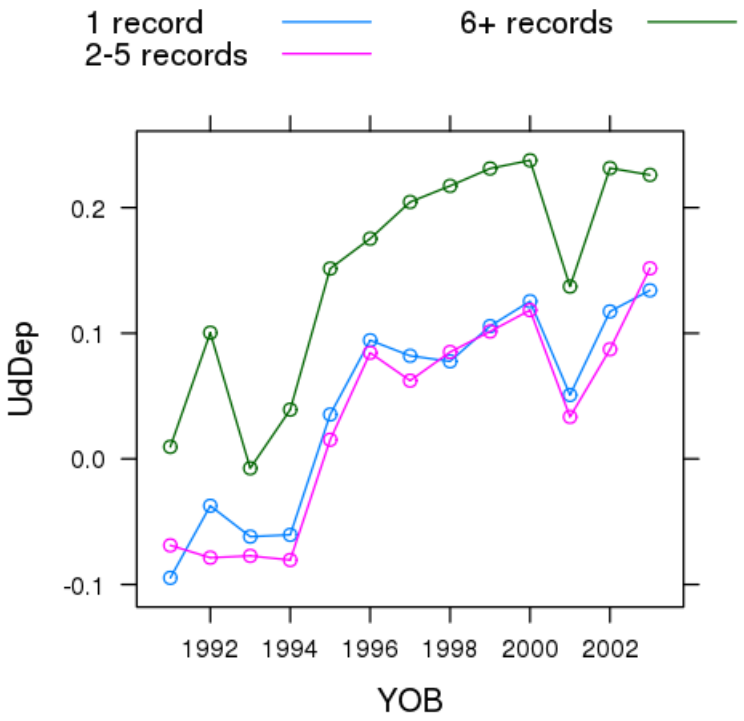


Figure 3. The trend of trait deviation for udder depth by year of birth (YOB) for survival categories: cows with 1 survival record, 2-5 survival records and 6+ survival records

a) Holstein



b) Jersey

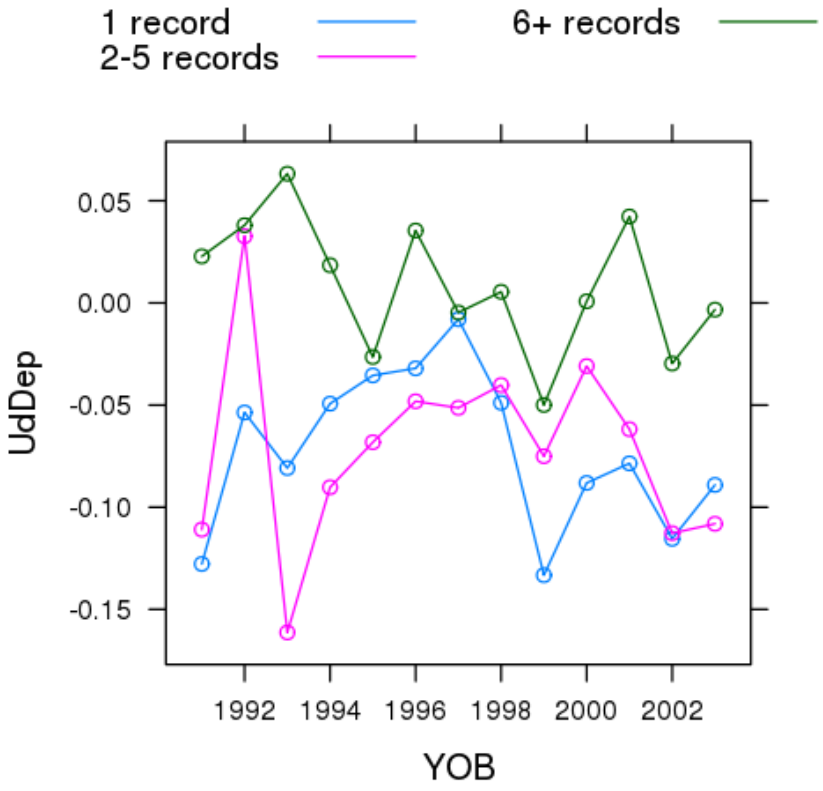
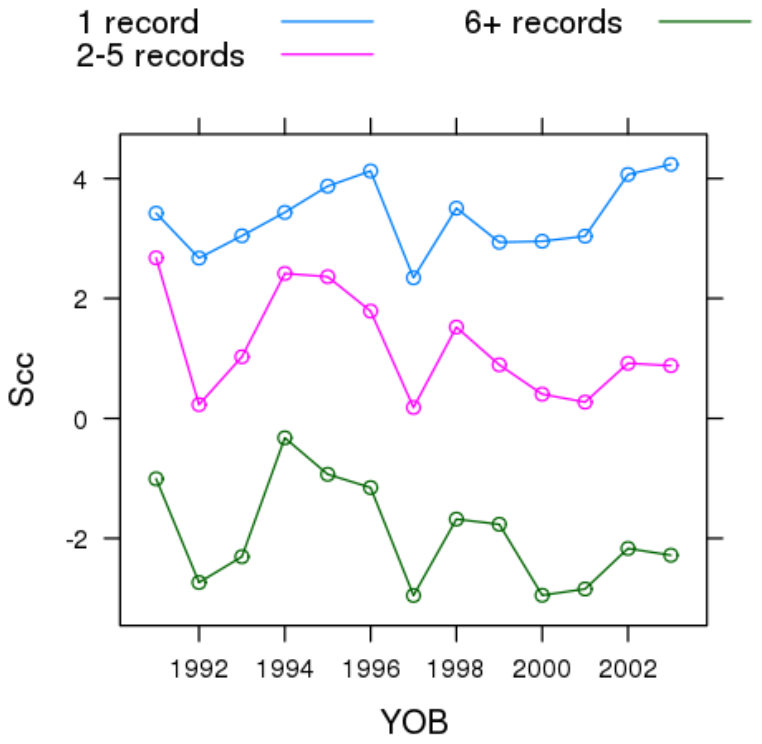


Figure 4. The trend of trait deviation for SCC by year of birth (YOB) for survival categories: cows with 1 survival record, 2-5 survival records and 6+ survival records
Holstein



Jersey

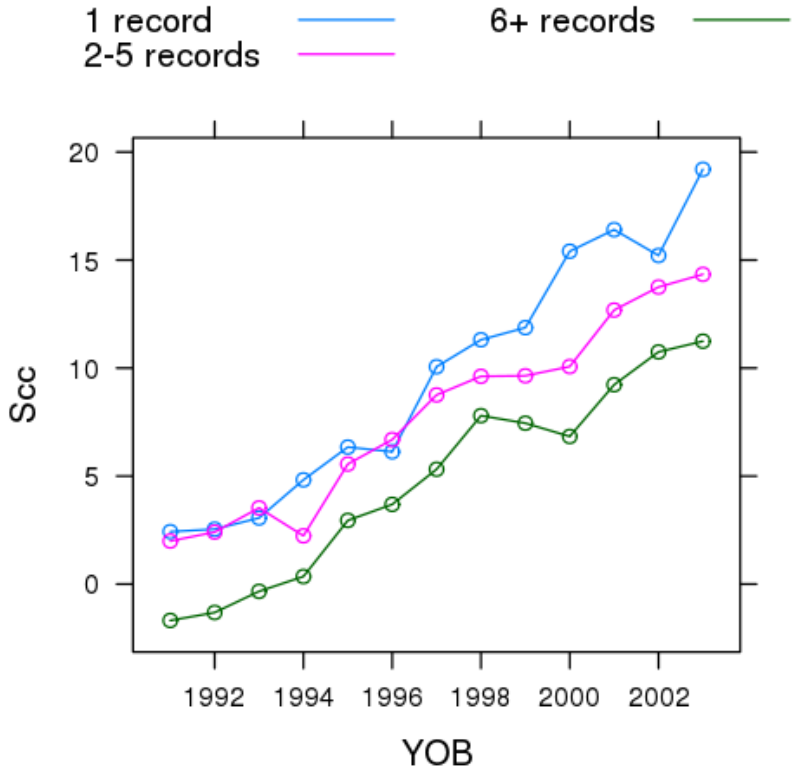
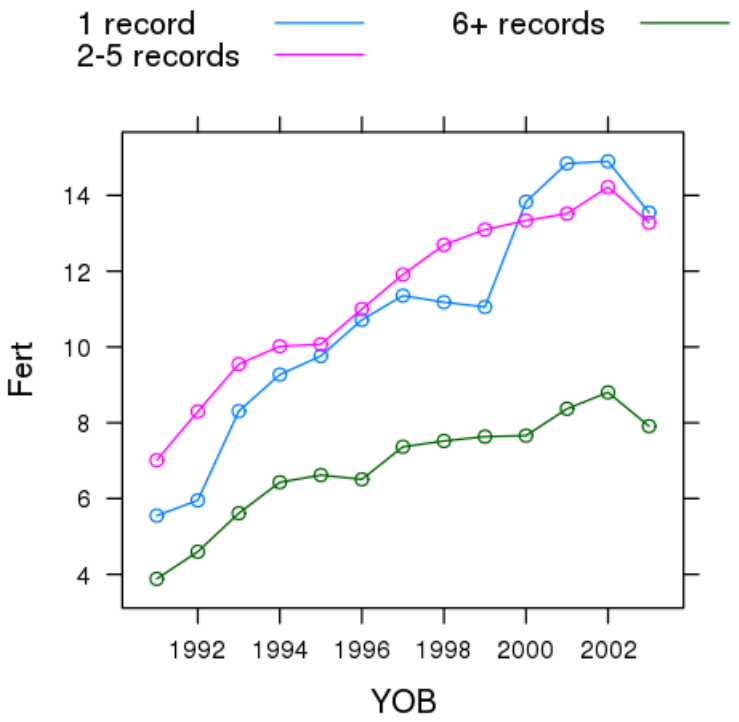


Figure 5. The trend of trait deviation for calving interval by year of birth (YOB) for survival categories: cows with 1 survival record, 2-5 survival records and 6+ survival records
Holstein



Jersey

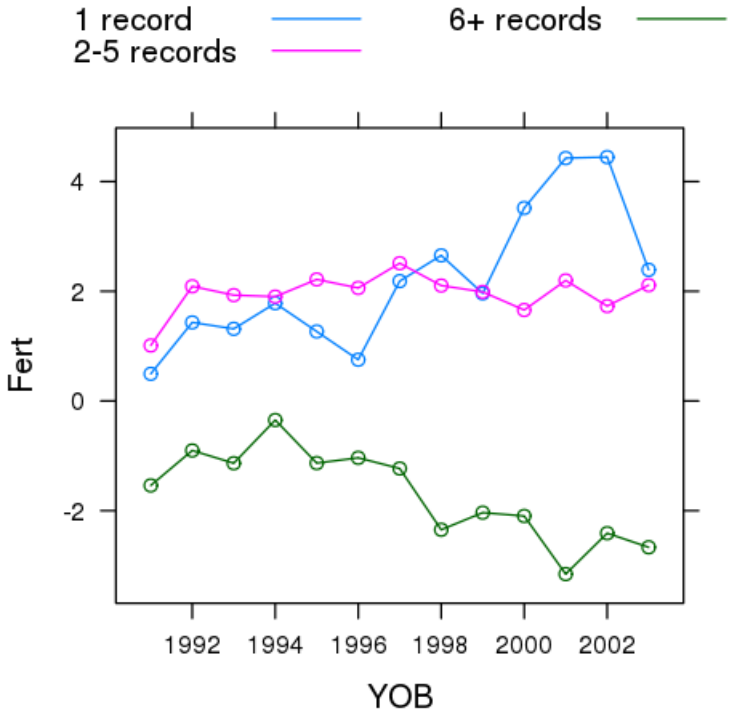


Figure 6. The trend of trait deviation for pin width by year of birth (YOB) for survival categories: cows with 1 survival record, 2-5 survival records and 6+ survival records Holstein