Preliminary Evaluation of Sire Fertility in Ireland

***Ross Evans*[1], *Sean Coughlan*[1], *and Donagh Berry*[2].**

[1]*Irish Cattle Breeding Federation, Highfield House, Bandon, Co. Cork, Ireland*

[2]*Teagasc, Moorepark Dairy Production Research Centre, Fermoy, Co. Cork, Ireland*

1. Introduction

Storing of mating information in the Irish Cattle Breeding Federation (ICBF) database began in 2005 although not all mating records were being recorded at that time. Currently, the vast majority of AI technicians record all artificial inseminations (AI) electronically which is updated daily to the ICBF database. Natural matings are also recorded voluntarily by the farmer.

Up until now male fertility of dairy and beef sires was only evaluated within breeding companies using raw averages for non-return rate. However, previous international research reported non-unity correlations between raw measures of male fertility and measures derived from mixed model equations that simultaneously adjust for confounding effects such as herd, month of service, age of cow, calving to service interval, semen price, and technician amongst others (van Doormaal, 1993; Reurink *et al.,* 1990).

The objective of this study was to determine the feasibility of producing nationally, indictors of male fertility for AI sires.

2. Materials and Methods

2.1 Data

A total of 1,004,093 records including artificial insemination (n=790,452) and natural mating (n=85,500) events as well as pregnancy diagnosis (n=128,141) events were obtained from the ICBF database from 1st January 2005 to 7th July 2007. An equal number of records were available in 2005 (n=307,401), 2006 (n=338,532) and 2007 (n=358,160). A total of 618,119 lactations (including maiden heifers as a separate parity) from 453,550 cows and heifers were represented in the dataset. Subsequent calving dates for 2006 and 2007 (where available) were also extracted and merged by cow to the 2005 and 2006 data, respectively.

Only cows of at least 75% Holstein-Friesian were retained; remaining breed fraction if present was coded as a single breed. Heterosis and recombination loss of the served cow as well as that resulting from the ensued mating were calculated; 801,234 service and pregnancy diagnosis records remained. Only meaningful service dates (i.e., animals served > 1 year of age or not in the periparturient period) from herd-years with at least 20 mating records were retained. Where mating events for the same cow occurred within 5 days of each other only the second record was retained. Contemporary group of herd-year-season of calving were generated using the algorithms of Crump *et al.* (1997). Contemporary groups with <5 records were removed.

In Ireland, breeding of lactating dairy cows usually commences around mid-April for a period of approximately 15 weeks. On average Irish farmers use AI for the first 6 weeks, after which natural mating is used. The end of the AI breeding season in the present study was defined as the last AI service record to a lactating cow in a herd-year where at least 10 matings in lactating animals occurred.

Only first mating records from lactating cows up to tenth parity were retained; parities >3 were grouped together. This included both AI and natural service to both dairy and beef sires. A variable reflecting sire status was generated where 1 = natural mating sire, 2= test sires (i.e., sire <5 years of age at the time of service) and 3 = proven AI sire (i.e., sire ≥5 years of age at service or sire date of birth missing). Limited information was available on the technician responsible for the service and no information was available on the batch number of the semen and whether the semen used was fresh or frozen.

Two binary fertility traits were defined: pregnant to first service (PFS) and 56-day non-return rate to first service (NR56). Animals with more than one service were immediately coded as not having held to the first service (PFS=0) as were animals scanned not in calf after first mating. If an animal was culled or died within 30 days post first mating then a missing value was allocated to PFS; a missing value was also given to animals that were served for the first time within 30 days of the last AI record within that herd-year.

In order to investigate the effect of information on subsequent calving dates on sire solutions an alteration on pregnant to first service (PFS_valid) was generated using the same criteria previously outlined but PFS_valid was coded as 1 if the subsequent gestation length was within 273 to 293 days post first mating (if inseminated with Holstein-Friesian semen) otherwise within 273 to 300 days. If gestation length was less than 273 days then PFS_valid was set to missing. The animal was assumed not to have held to first service if the subsequent gestation length was greater than 293 days (if inseminated with Holstein-Friesian semen) otherwise greater than 300 days.

56-day non-return rate of first service (NR56) was coded as 1 if the animal was deemed not to have returned to service within 56 days of first mating and otherwise zero. Animals that were served again within 56 days of first service were coded as zero. However, a missing value was given to animals served for the first time less than 56 days prior to the last recorded AI within herd-year or less than 56 days prior to culling or death. An alternation on NR56 was generated using calving dates in the subsequent year. If gestation length was less than 273 days then this trait (NR56_valid) was set to missing while a value of zero was given if the subsequent gestation length was greater than 293 days (if inseminated with Holstein-Friesian semen) otherwise greater than 300 days. NR56_valid was attributed a value of 1 if the subsequent gestation length was between 273 days and 293 days (if inseminated with Holstein-Friesian semen) otherwise between 273 and 300 days.

2.2 Analysis

All 4 traits were analysed separately in ASREML (Gilmour *et al.,* 2007) using an animal repeatability linear mixed model. Fixed effects included in the model were contemporary group of calving, parity of cow, age at calving nested within parity, heterosis and recombination loss of the cow and the resulting mating, an interaction between month of service and year of service, Friesian proportion of the cow, "other breed" proportion of the cow, quadratic effect of the interval from calving to first service, and status of service sire. Random effects included were an interaction between service sire and year of service (0, $\mathrm{I}\sigma_{SY}^2$), cow (0, $\mathrm{A}\sigma_A^2$), permanent environmental effect for cow (0, $\mathrm{I}\sigma_{PE}^2$), and residual (0, $\mathrm{I}\sigma_e^2$).

The solutions for each sire were summed with the solutions for the respective sire status. Mean PFS, PFS_valid, NR56 and NR56_valid were also calculated for each sire-year without adjustment for any confounding effects. Only sire-years with more than 50 first services were retained (n=316). Correlation analyses were undertaken to compare the solutions obtained from the linear model and the raw averages. Correlation analyses were also used to quantify the similarity in mixed models solutions per sire across each year.

3. Results and Discussion

Neither heterosis nor recombination loss of the cow or resultant mating significantly affected either of the four traits analysed. However, non-return rates and pregnancy rates improved with proportion Friesian genes and "other breed" genes in the cow relative to the Holstein. PFS and NR56 increased with days post-calving to day 102 and 46, respectively after which they declined. Both PFS and NR56 decreased with parity. The number of records, mean and variance components for the four traits analysed are presented in Table 1. The lower mean value of PFS_valid and NR56_valid compared to PFS and NR56, respectively indicates some level of underrecording of subsequent matings which may more than likely be natural matings. The large number of records for PFS_valid and NR56_valid is due to the missing value allocated to PFS and NR56 in cows served within 30 and 56 days, respectively of the last AI service within herd-year obtaining an actual value based on a subsequent calving. Although the proportion of phenotypic variance attributable to the sire by year interaction was small, the likelihood ratio test on nested models indicated that it was significant. However, inclusion of a sire-year random term in the model did not improve the log-likelihood of the model fit to both PFS traits compared to including only sire as a random effect. Correlations among sire solutions in 2005, 2006 and 2007 across all three traits varied between 0.21 (NR56_valid in 2005 and 2007) and 0.50 (NR56 in 2006 and 2007). Correlations between sire solutions in 2006 and 2007 were the strongest.

The variation in mixed model solutions for the 316 sire-years with more than 50 first services are summarised in Table 2 for the four traits analysed. A difference of between 10 to 16 percentage units were observed between extreme bulls.

Table 2. Standard deviation, minimum and maximum solutions for sire fertility.

Trait	SD	Min	Max
NR56	0.017	-0.058	0.051
NR56_valid	0.015	-0.055	0.047
PFS	0.024	-0.106	0.054
PFS_valid	0.024	-0.105	0.053

Table 1. Number of records (N), raw mean and phenotypic (σ_P), sire-year (σ_{SY}), additive genetic (σ_A), permanent environmental (σ_C) and residual (σ_e) standard deviation for the traits analysed.

Trait	N	Mean	σ_p(*100)	σ_{SY}(*100)	σ_A(*100)	σ_C(*100)	σ_e(*100)
PFS	173,872	0.56	46.6	3.4	4.4	6.6	45.8
PFS_valid	182,143	0.55	47.2	3.4	4.9	6.0	46.5
NR56	122,048	0.42	41.5	2.6	3.8	5.6	40.8
NR56_valid	125,057	0.40	41.4	2.5	4.0	5.3	40.8

Figure 1. Scatter plot of raw average NR56 against mixed model solutions for NR56 for AI dairy (■) and beef (x) sires with >50 first inseminations.

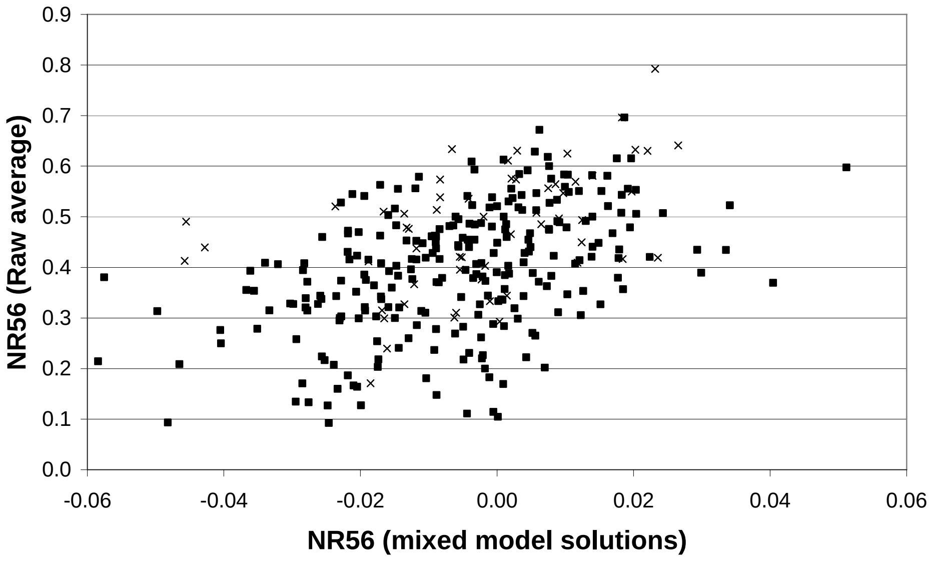

Table 3. Correlations between the four measures of sire fertility using solutions from mixed model equations (MME) or raw averages (raw).

Trait	PFS (MME)	PFS (Raw)	PFS_valid (MME)	PFS_valid (Raw)	NR56 (MME)	NR56 (Raw)	NR56_valid (MME)
PFS (Raw)	0.70						
PFS_valid (MME)	0.97	0.68					
PFS_valid (Raw)	0.65	0.94	0.68				
NR56 (MME)	0.81	0.56	0.78	0.52			
NR56 (raw)	0.49	0.45	0.46	0.34	0.46		
NR56_valid (MME)	0.79	0.54	0.79	0.52	0.97	0.45	
NR56_valid (Raw)	0.47	0.48	0.48	0.44	0.46	0.97	0.47

Figure 1 illustrates the association between the sire-year mixed model solutions for NR56 and associated annual raw averages; the correlation was 0.46 (Table 3). The non-unity correction between adjusted and unadjusted fertility measures (Table 3) indicates the importance of adjusting for confounding effects in the model of analysis.

4. Conclusions

With the rollout of the electronic recording service to most Irish AI technicians in 2007, complete identification of individual technicians should be possible which should be tested as a confounding variable in the model. An attempt should also be made to record semen batch number and whether the semen was fresh or frozen.

5. Acknowledgements

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6. References

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