DAYS TO CALVING IN ARTIFICIALLY INSEMINATED CATTLE

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SUMMARY

Heritability and cow permanent environmental effect (c^2) were estimated for various definitions of fertility for artificially inseminated (**AI**) cows. The most useful cow fertility trait was found to be the number of days from the date the first cow in the contemporary group was AI'd until each cow calved, with a penalty value for non-calvers. This trait mimics the equivalent trait for natural mating, the first AI date in a contemporary group being treated as the 'bull-in' date. Means and variances of the AI trait depend on how contemporary groups are defined, so various methods of defining contemporary groups are compared and discussed. Estimated heritability of AI days to calving (**AIDC**) was 5% with c^2 of 7-8%, broadly similar to current results for the equivalent BREEDPLAN trait for naturally mated cows. AIDC is therefore a potentially useful cow fertility trait; breeders interested in this trait should be encouraged to formally record contemporary groups of cows at mating.

Keywords: Beef cattle, Days to calving, Cow fertility, Artificial insemination, Genetic parameters

INTRODUCTION

Fertility of beef cows is an important aspect of profitable beef production (Ponzoni 1992). BREEDPLAN breeders are able to select for fertility of naturally mated cows by recording days to calving (**NMDC**). However, with increasing use of artificial insemination (**AI**), fewer cows have NMDC measurements. Fertility records of Angus AI cows were therefore investigated to determine if any useful measures of female fertility could be derived for cows mated by AI.

MATERIALS AND METHODS

Data. Records were obtained from the Australian Angus database, which is a total female inventory system used by seedstock herds participating in the BREEDPLAN genetic evaluation system. Data were amalgamated into one record per cow per season, comprising AI sire identifier, date of the initial AI, age of the cow at AI, number of days since the birth of any previous calf and, if the cow calved (either from the initial or subsequent AIs that season, or to a backup bull) the number of days from initial AI to calving, sex and sire of the calf, and whether a single or multiple birth. A total of 88185 amalgamated records from 1983-2001 were available from 643 herds and 4338 AI sires.

Checking/Validation. To create a consistent, easy-to-analyze dataset from the above, initial edits included deleting twin/multiple birth records (n = 1543), those of cows AI'd within 14 days of giving birth (104 additional records), cows over 10 years old at AI (3453), cows aged more than 3.5 years at AI but no record of a previous calf (1343) and cows with no record of a calf in the 1000 days before their AI (97). Records were then tabulated by herd to determine the percentages of inseminations resulting in a calf to the AI sire, a calf to another sire (e.g. a backup bull), or no calf at all. On average, 81% of cows had a calf to the AI sire (from either the initial or follow-up inseminations), 13% calved to another sire and 6% did not calve that season. However, in some herds, 100% of recorded cows calved to the AI sire. This suggested that, in some herds, the inventory system had not been successful in including the entire breeding population, so all herds with more than 90% of calves to the AI sires (263 herds with 27073 records) were excluded from the analysis. This left a

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total of 54572 records. Herds were then classified by number of AI records. In order to ensure contemporary groups were as large as possible and that all herds had considerable experience with use of AI, the current analysis was restricted to the 73 herds with more than 200 AI records, comprising a total of 39013 records from 21546 cows mated to 717 AI service sires and with 34126 animals in the cows' pedigree file.

Definition of contemporary groups (Cgps). In natural mating, days to calving is defined as the time interval between 'bull-in' date and the day the cow calves. Non-calvers are assigned a value equal to the maximum days to calving of their Cgp plus a penalty of 21 days, as recommended by Johnston and Bunter (1996). Cgps for natural mating are therefore readily identifiable by service sire/'bull-in' date. The AI data file contained no equivalent indicator of contemporary groups for AI calvings. The process of defining Cgps from the pattern of inseminations within each herd (or other subset of interest – see below) is illustrated in Figure 1 for a hypothetical and somewhat idealized example. Dates of each cow's initial AI are shown by vertical lines. Mating is usually seasonal (most often annually, but sometimes twice yearly), so records were split into seasonal groups whenever gaps of more than 50 days with no inseminations were encountered (see Figure 1). The seasonal groups were then split ('sliced') into Cgps according to the number of days between the first and last insemination in the grouping, called 'season_span' in Figure 1. To ensure equal time intervals for each group, the number of groups, ncgp, was calculated as (1 + season_span/max_slice) where max_slice is the maximum desired number of days between the first and last insemination in a Cgp. Records were then split into ncgp Cgps, each covering a time interval of (season_span/ncgp) days. Three different values were considered for max_slice: 60 days (the value used in BREEDPLAN to slice contemporary groups by age of animal), 90 and 120 days.

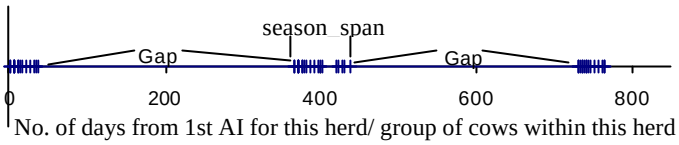

Figure 1. Illustration of how contemporary groups were formed.

In natural single-sire mating, Cgps have only a single service sire, so they are necessarily confounded with service sire. Three possibilities were considered for the subgroups of cows within a herd from which to form AI contemporary groups: **H**) the entire herd; **M**) using subgroups for mature cows > 1.9 years at AI, and heifers, so that the heifers in each herd are in separate Cgps to mature cows and **MS**) treating mature cow/heifer x AI service sire as the basic subgroup from which Cgps were formed by the process shown in Figure 1.

Synchronization. For each herd, the mean number of days per Cgp on which cows were AI'd was used to investigate whether cows were synchronized before AI. For Cgp M, means ranged from 2.3 (strongly indicative of synchronization) to 37.6 (suggesting natural heat detection). About 25% of herds averaged < 6 days per Cgp. All data were included in the current analysis, but it may be possible in future to use this criterion to predict if a Cgp was synchronized and examine the effects.

Definition of traits. Four main traits were considered: **A**) For cows calving to the AI sire, number of days from that cow's initial AI to calving. Though some cows had repeat inseminations, the vast majority calved from their first AI, so this trait resembles gestation length. **B**) For all cows that calved (either from AI or a backup bull), number of days from that cow's initial AI that season to calving. **C**) As B) for cows that calved; non-calvers were also included in C and given the maximum

of trait B for all cows in the contemporary group, plus a penalty of 21 days. **D**) Define the 'start date' for a contemporary group as the date the first cow in that group was inseminated. For cows that calved, trait D was calculated as the number of days from the 'start date' to the day of calving. For non-calvers, trait D was defined as the maximum of trait D for all cows in the group that calved plus a penalty of 21 days. The latter trait was chosen to mimic days to calving in a naturally mated herd, assuming contemporary groups are the basic management unit and that, after detecting heat and inseminating the first cow in the group, other cows will be monitored and AI'd when ready. Basic statistics, including means and population variances, are given in Table 1. Numbers of records vary, because those for contemporary groups of size 1 were deleted to minimize computing time. Note that means and especially variances of trait D depend on how contemporary groups were formed.

Analysis. Data were analyzed using VCE4 (Groeneveld and García-Cortés 1998). The basic model was: trait = a + c + calf_sex + cow_age_class + α_1(age$_1$-m$_1$) + α_2(age$_2$-m$_2$) + lactation_status + contemporary_group + initial AI sire (if appropriate), where a = the additive genetic effect of the cow (with variance Aσ^2_a where A is the NRM); c = the permanent environmental effect of the cow (with variance Iσ^2_c). Fixed effects fitted were: calf_sex – a covariate to adjust for the sex of the calf (-1 for male, 1 for female otherwise 0), cow_age_class had 6 levels based on the age of the cow at AI (<1.9, 2.9, 3.9, 4.9, 5.9 or > 5.9 years), age$_1$-m$_1$ and age$_2$-m$_2$ are covariates for the linear effect of age within age classes 1 and 2 (otherwise zero), lacatation_status was wet for cows calving less than 160 days before her AI (< 150 days of the first AI in the contemporary group for trait D), otherwise dry. If initial AI sire was not included in the definition of contemporary group, it was fitted as an additional fixed cross-classified factor. All runs converged satisfactorily (VCE status 1).

Table 1. Numbers of records, contemporary groups (Cgps), means, variances and estimates of h^2 and c^2 for all traits (with max_slice = 120 days) and natural mating DC in the same herds

Trait_type	**A**	**B**	**C**	**C**	**C**	**D**	**D**	**D**	**Natural**
Records included[1]	**A**	**AB**	**All**	**All**	**All**	**All**	**All**	**All**	**Mating**
Cgp definition[2]	**MS**	**MS**	**MS**	**M**	**H**	**MS**	**M**	**H**	**DC**
Number of records	28019	34416	37255	38818	38908	37255	38818	38908	50889
Mean (days)	280.9	287.0	291.4	292.6	293.1	300.2	305.4	308.9	310.1
Variance (days^2)	52	273	538	674	732	720	946	1046	662
No. of Cgps	4181	4316	4316	1335	917	4316	1335	917	5722
Phenotypic variance	40	224	435	555	615	534	671	754	480
Direct heritability (h^2, %)	12.6	3.0	3.3	2.9	3.0	4.7	4.1	5.3	3.2
Cow perm. env. (c^2, %)	1.6	2.7	4.7	5.0	5.2	8.1	7.9	6.9	6.1

[1]A = cows calving to AI; AB = cows calving to AI or backup bull; All = all cows. [2]Contemporary groups were defined using the procedure shown in Figure 1 on subgroups of each herd; H = entire herd, M = maturity class (older/younger than 1.9 years at AI), MS = M x AI sire.

RESULTS AND DISCUSSION

Table 1 shows results for all traits using contemporary groups defined with max_slice = 120 days.

Estimated heritability (h^2) for Trait A (days to calving for cows calving to the AI sire, a trait analogous to gestation length, as demonstrated by its mean of 280.9 days) was 13%. Permanent environmental effect of cow, c^2, was relatively low at 1.6%. Including data for cows calving to the backup bull (trait B) substantially increased variances and reduced h^2 to 3%. Extending to trait C, by including non-calvers (given the maximum of their contemporary group plus a penalty of 21 days) effectively doubled the variance but estimated h^2 remained at 3%; there was a marginal increase in c^2 to 5%. Trait D was estimated to have h^2 of 5% with c^2 of 7-8%. Thus the trait mimicking the equivalent trait for natural mating was found to be more heritable and have higher c^2.

Effect of alternative contemporary group definitions. Table 2 shows means, variances, h^2 and c^2 for traits A and D, defined using the alternative values for max_slice of 60 and 90 days. Results were generally similar to those for max_slice of 120 days, though both h^2 and c^2 tended to be marginally lower. The highest h^2 estimate of 5.3% was for contemporary groups defined using only herd as the major grouping and with max_slice of 120. However it is debatable whether cows aged less than 1.9 years at AI will be managed in the same group as older cows. Thus the estimates of h^2 = 4.7% and c^2 = 8.1% based on contemporary groups defined from herd x maturity x AI service sire (Table 1) are the most realistic estimates. These values are lower than estimates published by Johnston and Bunter (1996), but comparable to BREEDPLAN NMDC in the same herds (Table 1). Further research, to be reported elsewhere, indicates that genetic correlations between AIDC and NMDC are high (> 0.6) and correlations between c^2 for the two traits are in excess of 0.9.

Table 2. Numbers of records, animals, contemporary groups (Cgps) and estimates of h^2 and c^2 for traits A and D using alternative values for max_slice of 60 and 90 days

Cgp. slicing	60 days				90 days			
Trait_type [1]	A	D	D	D	A	D	D	D
Cgp definition[1]	MS	MS	M	H	MS	MS	M	H
Number of records	27904	37114	38727	38846	28007	37238	38809	38898
Mean (days)	280.9	298.4	301.8	304.0	280.9	299.6	303.9	306.8
Variance (days^2)	52	629	761	825	52	687	845	926
No. of Cgps	4365	4504	1549	1140	4324	4359	1401	988
Phenotypic variance	40	490	597	657	40	521	637	710
Direct heritability (h^2, %)	12.9	4.7	3.9	4.4	12.7	4.5	3.6	4.5
Cow perm. env. (c^2, %)	1.8	7.2	6.4	5.4	1.6	8.1	7.3	6.5

[1] See footnote to Table 1 for explanation of terms.

CONCLUSION

Estimated heritability of AI days to calving (trait D and max_slice of 120) was 5% with c^2 of 7-8%, broadly similar to current results for the equivalent BREEDPLAN trait for natural mating. AIDC is therefore a potentially useful cow fertility trait; breeders interested in this trait should be encouraged to formally record contemporary groups of cows at mating and whether cows were synchronized.

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