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## Heritability of puberty traits in dairy heifers in commercial herds

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### ABSTRACT

Age and weight at puberty (first behavioural oestrus) are known to be heritable traits in experimental beef and dairy cattle. The recording required is usually labour-intensive, and may also be expensive if serial blood samples are taken to estimate progesterone concentrations. Our objective in this study was to ascertain whether a less labour-intensive approach for estimating age at puberty (AP) would still provide enough statistical power to show genetic variation among sire groups of Friesian and Jersey heifers grazing in large groups. Commercial heifers ( $n = 797$ ) were born in the late winter/early spring of 2002, and were predominantly the result of artificial insemination (AI) matings. They were reared to weaning in six herds, and then grazed in five herds through 2003. Tailpaint was applied to heifers at visits to the grazing herds at 4-6 week intervals, and tailpaint loss was recorded at each visit to determine approximate date at puberty. Birth dates were known, and hence AP was calculated. The heritability of yearling live weight (W12) was used as a control measure. From four of the herds ( $n = 453$ ), there were animals by 13 widely-used AI sires (9 Friesian and 4 Jersey), and 10 other sire groups were represented with at least 5 daughters each. The phenotypic standard deviations for AP and WP were 48 days and 34 kg, similar to that found in New Zealand experimental beef cattle herds. The pooled within-breed heritability estimates for AP, WP and W12 were  $0.09 \pm 0.10$ ,  $0.21 \pm 0.14$  and  $0.24 \pm 0.15$ , respectively. Confounding of AI sire group with date of birth of heifer was encountered. The breeding-value difference in AP between the top 7 and bottom 6 of the widely used AI sires was 15 days, or 1.05 genetic standard deviations. In conclusion, recording AI calves in large grazing herds may be a practical method of getting access to puberty data, but more frequent visits to each herd would probably be needed to reduce the noise, and increase the heritability for AP and WP.

**Keywords:** cattle; puberty; heritability.

### INTRODUCTION

Age at puberty (AP) and weight at puberty (WP) are heritable traits in experimental heifers managed under grazing conditions (Morris *et al.*, 1992; 2000). Heritability estimates from our latest experiment were  $0.27 \pm 0.04$  for AP and  $0.44 \pm 0.06$  for WP (Morris *et al.*, 2000), where heifers were reared on beef cows. An estimate for AP from 3593 experimental beef heifers in the USA was 0.47 (Splan *et al.*, 1998).

The purpose of the present study was to determine whether it is possible with dairy-origin heifers to estimate heritabilities of similar magnitude to those for AP and WP from other New Zealand studies (and hence assess genetic differences in puberty among animals), when recording is only possible at 4- to 6-week intervals, rather than at least weekly as in our experimental herds. With these extended and sub-optimal recording intervals, is it possible to determine genetic variation when loss of tailpaint could also occur from causes other than from standing oestrus (i.e. hair loss with the loss of the winter coat, and difficulty in reading tailpaint because of general dirtying of the paint with mud or faecal matter from the tail)?

If AP and/or WP could be recorded cheaply and accurately in dairy heifers, this would be beneficial to dairy farmers, because of the possible genetic correlations with other reproductive traits currently used as predictors in the New Zealand dairy industry's "Breeding Worth" summaries.

### MATERIALS AND METHODS

*Animals.* A total of 797 heifers of dairy origin were recorded, including Friesians, Jerseys and crosses between them. They were born in late winter/early spring (July to September 2002) in six herds, and were sired predominantly by artificial insemination (AI) sires, with some sires in common among four of the herds. They were weaned from their dams within a few days of birth, reared on milk or milk substitutes for 2-3 months ('bucket-rearing') before being grown out predominantly on pasture. By their first autumn, when recording for puberty began, the heifers had all been moved from their herds of origin. They were grazing in six mobs on five properties: four properties being in the western King Country (where we received assistance with access via the New Zealand Grazing Company) and one in the Wanganui district (AgResearch's Flock House farm).

*Recording.* Date at puberty in these heifers was defined as the time of first behavioural oestrus, determined from the loss of tailpaint. Visits to the five properties were timed to coincide with other stock-handling operations, at 4- to 6-weekly intervals, and tailpaint was re-applied to each animal where necessary, at each visit after the first. Details of dates, numbers of times that the herds were visited, and percentages of animals reaching puberty by the last visit in October or

November 2003 are given in Table 1. The average mob size was 133 (range 102 to 169).

**TABLE 1:** Number of heifers, dates and number of visits to record puberty, and percentage of heifers cycling at the final visit in each herd.

Herd <sup>1</sup>	No.	Recording period	No. of recordings	% cycling at end
1	169	7 Mar to 20 Oct	13	98%
2	119	25 Apr to 16 Oct	6	90%
3	131	12 May to 16 Oct	5	93%
4	161	10 Mar to 4 Nov	8	100%
5	115	12 May to 16 Oct	5	93%
6	102	23 Apr to 29 Oct	6	99%

<sup>1</sup> Herds 1-4 comprised the data for heritability analysis; some heifers in each herd were discarded as being progeny of seldom used sires.

Birth details (date of birth, age of dam, sire identification) were obtained from the heifers' owners, and AP was determined from the dates of birth and puberty. Live weights were recorded at regular intervals, and WP was determined by interpolation from the live weights.

*Data analyses.* Four of the herds (n=453 heifers) were linked for the purpose of data analysis by 13 widely-used AI sires (9 Friesian and 4 Jersey), and 10 other AI sire groups in these four herds were represented with at least five daughters each. In the other two herds, there were no common reference sires linking their progeny groups to those in other herds. The records of W12, AP and WP from these animals were analysed to obtain heritability estimates using an animal model with two generations (and in some cases three generations) of pedigree on the male side, using restricted maximum likelihood (REML) procedures (Gilmour, 1997). The following effects were tested: age of dam, breed of sire and mob as fixed effects, and date of birth within mob as a covariate. In additional analyses, the AP trait was also transformed in two ways, either to a binomial (logit and probit analyses of whether a heifer had reached puberty before/after the median animal in the mob), or into three parts (whether an animal reached puberty by June 30, from then until September 30, or from October 1: overall in our data this corresponded approximately to the first 15%, the middle 55%, and the last 30% of the heifers). These transformations were tested because our main aim in ranking animals (and hence their sires) was to divide the heifers (i) into two groups (early or late), or (ii) into three groups according to whether they were early, similar to the majority, or late.

The possible confounding of sire with date of birth was investigated, by estimating the heritability of date of birth (the estimate should be non-significant if birth dates of calves by different sires are random).

## RESULTS

Heritability estimates for AP, WP and W12 are shown in Table 2, using the models which fitted effects for herd of origin, breed of sire, and age of dam. W12 had a heritability of  $0.24 \pm 0.15$ , showing that a single, simple trait was heritable under these farm conditions. AP had only a low heritability estimate ( $0.09 \pm 0.10$ ) as a normally distributed trait. The phenotypic standard deviation for AP was 48 days (12% of the mean). This parameter remained about the same when heifer date-of-birth was also fitted as a covariate, but the heritability for AP then fell to almost zero ( $0.01 \pm 0.07$ ; not tabulated). The apparent heritability for heifer's date of birth itself was  $0.40 \pm 0.19$  (not tabulated), suggesting that sire effects were significantly confounded with date of birth. The regression of age at puberty on date of birth was  $-0.49 \pm 0.17$  days per day ( $P < 0.01$ ), indicating that calculating ages from dates at puberty still left a relationship with date of birth. The heritability estimate for AP was not improved by converting it to a 0/1 or early/mid/late scale. However, using AP as a normally distributed trait, it was still possible to find usable breeding-value differences among sires: between the top 7 and bottom 6 of the widely used AI sires, there was a difference of 15 days, or 1.05 genetic standard deviations.

**TABLE 2:** Heritability ( $h^2$ ) estimates and phenotypic standard deviations for age at puberty, weight at puberty and yearling live weight (n = 453 records; 23 artificial insemination sire groups).

Trait	$h^2$	Standard deviation
Age at puberty (d)	$0.09 \pm 0.10$	48.2
Puberty class 0/1	logit $0.05 \pm 0.06$	
	probit $0.06 \pm 0.08$	
	0/1/2 $0.08 \pm 0.09$	
Weight at puberty (kg)	$0.21 \pm 0.14$	33.9
Yearling weight (kg)	$0.24 \pm 0.15$	22.4

The heritability for WP was higher than for AP at  $0.21 \pm 0.14$ , and its phenotypic standard deviation was 33.9 kg (13% of the mean). The genetic correlation between AP and WP was large and positive at  $0.61 \pm 0.40$ , and an alternative estimate of the heritability of AP, adjusted by regression for WP, was  $0.12 \pm 0.11$ . Estimates of genetic correlations of AP with W12 were  $-0.11$  and  $0.40$  (respectively with and without adjustment for date of birth).

## DISCUSSION

For AP, heritability estimates were low, whatever definition of AP was used. One serious factor appeared to be the significant confounding of sire group with date of birth. Other possible explanations could have been rearing effects before moving to the beef-rearing farm, but we had no method of allowing for these (e.g. factors such as number of weeks reared on milk, or

age/weight at weaning, may not have been constant within a herd). Heritability estimates for AP from two earlier studies on New Zealand research stations (Morris *et al.*, 1992 and 2000) were larger at  $0.32 \pm 0.10$  and  $0.27 \pm 0.04$ , respectively.

Phenotypic standard deviations for W12, AP and WP were similar in the present data (22 kg, 48 d and 34 kg) to those in our beef research herd (24 kg, 52 d and 32 kg: Morris *et al.*, 2000), so variability was not limiting in our present data. It is possible that sire variance for puberty traits may have been truncated, but this effect would probably have been small unless there was a large genetic correlation with milk yield traits (i.e. the traits mainly used for selection when the sires in question were selected).

For W12 and WP, heritability estimates in the present data were much larger at 0.24 and 0.21 than for AP, although still lower than the estimates from beef heifers reared together in one research-herd environment ( $0.25 \pm 0.06$  and  $0.40 \pm 0.13$ , respectively: Morris *et al.*, 1992; and  $0.39 \pm 0.03$  and  $0.44 \pm 0.06$ , respectively: Morris *et al.*, 2000).

### CONCLUSIONS

It is concluded that levels of phenotypic variability for AP and WP were as expected, but the genetic components were less than found under research-herd conditions, especially for AP. Nevertheless, it was possible to rank the more widely-used AI sires for AP and WP from this field data, and this may be of use in future genetic evaluations.

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