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## Genetic parameters for live weights in fallow deer (*Dama dama L.*)

C.A. MORRIS, J.E. MCCALL, R.L. BAKER AND B.R. SOUTHEY

AgResearch, Ruakura Agricultural Centre, Private Bag 3123, Hamilton, New Zealand.

### ABSTRACT

Analyses of live weights at birth, weaning (4 months of age) and at the yearling stage from 360 fallow deer born in 1988 to 1990 were carried out to examine non-genetic effects and to provide preliminary estimates of heritability and genetic correlations. Weights of breeding does were also analysed. Fifteen sires (17 mating groups) were involved, with 2 sires repeated across years. After adjustment for fixed effects, coefficients of phenotypic variation were 10.5, 8.2 and 5.7% respectively for the three weights. The range of birth dates within year, excluding 3 outliers, averaged 36 days (s.d. 7.9 days). The differences in weight between males and females were 0.27, 2.5 and 9.3 kg at birth, weaning and the yearling stage. Regressions of live weights on birth date were zero,  $-0.15 \pm 0.01$  and  $-0.10 \pm 0.02$  kg/day, respectively. Heritability estimates were  $0.22 \pm 0.17$ ,  $0.29 \pm 0.19$  and  $0.41 \pm 0.23$ . Phenotypic correlations among weights of deer up to 12 months of age averaged 0.41, and genetic correlations averaged 0.35. Phenotypic correlations among weights of breeding does averaged 0.68 and the repeatability of doe weight was  $0.57 \pm 0.04$ .

**Keywords** Fallow deer, body weight, heritability, genetic correlation.

### INTRODUCTION

Little has been published about the genetics of production traits in farmed fallow deer (*Dama dama L.*). This report provides preliminary estimates of heritabilities and correlations for live weight traits in young fallow deer, along with a summary of non-genetic factors affecting these traits. The live weight data on does in the breeding herd are also reported.

The species consists of 2 subspecies, the European fallow deer, *Dama dama dama*, and the Mesopotamian fallow deer, *D. d. mesopotamica* (Whitehead, 1972).

### MATERIALS AND METHODS

#### Animals

The data were obtained from the first three fawning years (1988-90) of a nucleus herd of fallow deer, run on a property 20 km east of Tirau (South Waikato) in 1988 and 1989, and then transferred to a property 10 km north-west of Whangarei prior to fawning in 1990.

Foundation does born in 1986 on 18 breeders' properties were screened into the nucleus farm, mainly on yearling weight. There were in total 105 does mated in balanced single-sire groups to bucks in April/May 1988. A further 34 yearling does were screened on the same basis in autumn 1989 from the same 18 breeders, and similarly 37 yearling does in 1990. In autumn 1990, 20 selected females born in the herd in 1988 were also mated. Existing females in the herd were also re-mated each year.

Five bucks from five different properties were used for mating in 1988; six bucks were used in 1989, with one repeated from the previous year; six bucks were also used in 1990, again with one repeated from the previous year. There were thus 15 individual sires and 17 mating groups, with sires randomised to animals of each age group. Over the 3 years, 10 New Zealand herds were sampled for bucks, and one nucleus-bred buck was used in 1990. In 1989, the bucks also included one half Swedish-half New Zealand animal (*D.d. dama*), and, in 1990, they included

one half Mesopotamian (*D.d. mesopotamica*) - half New Zealand buck and two purebred European bucks (one from England and one from Hungary). All does conceived to natural matings, except those to the Hungarian buck where synchronous artificial insemination was used.

#### Management

Does fawned in five similar management groups (balanced across mating sire) in 1988 and again in 1989. Does of different age were in separate groups in 1989. In 1990, the herd was subdivided into 7 groups; age and management group were confounded. Fawning each year began in December and was completed in January. Fawns were tagged, identified to dam within 24 h of birth and weighed. Management groups were maintained intact until weaning (approximately 4 months of age). After weaning, the animals born in 1988 and 1989 were managed in one group per year until the December (yearling) weight. The animals born in 1990 were drafted into 2 groups of each sex in May, and were managed in these four groups until the yearling weight in November.

#### Data analysis

Preliminary analyses were undertaken using Genstat (1988), to determine appropriate fixed effects models. Finally, the restricted maximum likelihood (REML) programme of Meyer (1986) was used with a mixed model, to estimate heritabilities and phenotypic and genetic correlations (multivariate analysis). The mixed model consisted of the following fixed effects: year x age of dam x management group, sex of fawn and a covariate for date of birth; 'sires' were taken as the random effect. For the yearling weights of animals born in 1990, sex was confounded with management group; the sex effect reported here came from the animals born in 1988 and 1989 only.

Weights of breeding does in the herd were also recorded in March 1988, March 1989, August 1990 and April 1991. Correlations were estimated among these weights, after adjustment for fixed effects. In a second analysis, repeatability of doe weight was

estimated after fitting fixed effects for year of birth, year of measurement and their interaction. Similar analyses were also carried out for 1988- and 1989-born does in the herd (i.e. only does with a known sire), with the addition of a random effect for sire of animal. Finally, a repeatability estimate for fawning date in 1988-90 as a doe trait was obtained, using 137 does born in 1986 and 1987, and adjusting for sex of fawn, year of birth, year of fawning, and buck within year as fixed effects.

## RESULTS

### Fixed effects

Table 1 shows the numbers of records, means, phenotypic standard deviations (after adjustment for fixed effects) and the coefficients of variation for each trait. Coefficients of variation fell from 11 to 8 to 6% for birth, weaning and yearling weights respectively.

Sex of fawn had a significant effect at all ages ( $P < 0.01$ ). Differences between sexes (male minus female) were  $0.27 \pm 0.04$ ,  $2.5 \pm 0.2$  and  $9.3 \pm 0.3$  kg, for birth, weaning and yearling weights respectively.

**TABLE 1** Numbers of records, means (kg), phenotypic standard deviations (kg) and coefficients of variation for live weight traits.

Item	Birth weight	Weaning weight	Yearling weight
Number of records	360	304	294
Mean	3.7	19.3	37.1
Standard deviation <sup>a</sup>	0.39	1.58	2.13
Coefficient of variation	10.5	8.2	5.7
Regression on date of birth (d <sup>-1</sup> )			
: estimate	-0.001	-0.15	-0.10
: s.e.	0.003	0.01	0.02

<sup>a</sup> After adjustment for fixed effects.

Excluding one early and two late fawns, the ranges of fawning dates were 36, 38 and 35 days in 1988, 1989 and 1990, respectively, and the standard deviation within year averaged 7.9 days. Including the three outliers, 87.5% of fawns were born in the first 21 days. Table 1 also shows the regressions of live weight on date of birth for each trait, from the REML analysis.

Age of dam effects were not estimable, independently of management group, because of the management procedures used, as described above.

### Random effects

Table 2 shows the heritability estimates from the multivariate analysis. Estimates were generally intermediate in size, although the small numbers of sires (15) precluded small standard errors. Table 2 also shows the phenotypic and genetic correlations among the 3 traits, averaging 0.41 and 0.35 respectively. The phenotypic and genetic correlations between birth and yearling weights were notably lower than the other two.

Application of a maternal and direct effects model for birth weight generated heritability estimates of 0.27 (direct), 0.64 (maternal, i.e. maternal variance/total phenotypic variance) and a genetic correlation of -0.56 between them. Corresponding values for weaning weight were 0.27, 0.45 and -0.64.

A heritability estimate was also obtained for fawn survival to weaning, giving a value of  $0.07 \pm 0.11$ . The mean birth weight of the 56 animals which died before weaning (3.32 kg) was

**TABLE 2** Heritabilities (multivariate analysis), phenotypic<sup>a</sup> and genetic correlations for live weight traits up to the yearling stage.

	Birth weight	Weaning weight	Yearling weight
Birth weight	0.22 <sup>b</sup>	0.45	0.25
	0.17	0.05	0.06
Weaning weight	0.45	0.29	0.52
	0.42	0.19	0.05
Yearling weight	0.19	0.41	0.41
	0.47	0.37	0.23

<sup>a</sup> Phenotypic correlations above the diagonal, and genetic correlations below; heritabilities are on the diagonal.

<sup>b</sup> The first row of each pair provides the parameter estimate, and the second row its standard error.

significantly lower ( $P < 0.01$ ) than that of the 304 surviving animals (3.74 kg).

Phenotypic correlations among weights of breeding does averaged 0.68, with a range from 0.58 to 0.73. The repeatability of doe weight from 4 years' data was  $0.57 \pm 0.04$ , and the heritability estimate (2 years' data only; 10 sire groups) was  $0.92 \pm 0.65$ . The repeatability estimate for fawning date was 0.01  $\pm$  6.90%, and not significantly different from zero.

## DISCUSSION

### Fixed effects

It has been a belief in the fallow deer industry that the species is highly inbred and shows little variation (Pemberton and Smith, 1985). It was therefore of interest to find that coefficients of variation for birth, weaning and yearling weights were 10.5, 8.2 and 5.7% respectively (Table 1), compared with values of 12.1, 10.9 and 7.6% for red deer in New Zealand (Rapley 1988) and 13.3, 12.6 and 10.1% for beef cattle in New Zealand (Morris *et al.*, 1992). Coefficients of variation for fallow deer were only slightly smaller than for red deer, although studies in red deer (e.g. Hartl *et al.*, 1990) have revealed more polymorphisms than in fallow deer (Pemberton and Smith, 1985).

With the present fallow data, discarding the weights of fawns by foreign sires hardly changed the standard deviations (respectively 103%, 106% and 92% of the values from the complete data set). The fawning date distributions (which would affect the regression covariates of weight on age) were similar for animals sired by local or foreign sires, except for the Hungarian-sired fawns whose dams were synchronously mated by artificial insemination.

Asher and Adam (1985) have previously reported on fixed effects for the birth and weaning weights of fallow deer fawns ( $n=121$ ). Compared with Table 1, their values were respectively 3.7 and 18.1 kg for the means,  $0.011 \pm 0.005$  and  $-0.196 \pm 0.013$  kg/d for regressions on date of birth, and 0.4 and 2.1 kg for sex effects (0.3 and 2.5 kg in the present data).

### Random effects

Heritability estimates obtained in Table 2 for fallow deer were similar to averages of New Zealand beef cattle values of 0.31, 0.18, 0.36 respectively (Table 9 of Morris *et al.*, 1992), within the limits of the standard errors. In contrast, the values for weights of red deer in New Zealand at birth, weaning and 15 months were  $0.67 \pm 0.29$ ,  $0.77 \pm 0.15$  and  $0.60 \pm 0.22$  (Rapley 1990), although she commented that the calving of hinds still

maintained in their mating groups may have inflated estimates in her data. There may also have been some problems in interpretation with wapiti hybrids. Very recently, other heritability estimates have been reported from red deer in Scotland by McManus and Hamilton (1991), with values of  $0.27 \pm 0.04$ ,  $0.21 \pm 0.06$  and  $0.10 \pm 0.05$  respectively for the birth, weaning and yearling weights of 430 calves.

Further analyses with our data, without the foreign sire groups included, were unsuccessful at showing any heritability estimates significantly different from those reported in Table 2. However, to test this with greater power would require much larger numbers of sire groups.

Phenotypic correlations (Table 2) were positive and of intermediate size, as expected. Figures derived from the results of Asher and Adam (1985) led to a phenotypic correlation of 0.28 between birth and weaning weights, compared with 0.45 in our data. The genetic correlations were subject to large sampling errors and need to be re-estimated from a larger data set eventually, but these preliminary values had positive signs as expected. The genetic correlations between maternal and direct effects for birth weight and for weaning weight were large and negative; again more data are required, to reduce standard errors. Corresponding estimates in beef cattle are generally close to zero (Meyer 1992).

The tight fawning span observed here was consistent with data reported by Asher (1988). In red deer, McManus and Hamilton (1991) reported a standard deviation of 11.4 days, compared with our value for fallow deer of 7.9 days, although their repeatability of calving date ( $17 \pm 2\%$ ) was larger than in our study ( $0.01 \pm 6.90\%$ ).

The practical implications of these findings are that there is useful variability in fallow deer from which to select for greater weaning or yearling weights.

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