ESTIMATIONS OF REPEATABILITIES AND HERITABILITIES OF WEIGHTS IN REINDEER.

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SUMMARY

Genetic and phenotypic paramaters for weight at 2, 7 and 19 months of age were estimated in reindeer. The study was conducted using around 5500 records from an additional tagged reindeer herd in Sweden. Data from the years 1986 to 1990 were used in the analysis. Phenotypic variances in live weight were estimated. In a selected population, within-individual variance was higher than between-animal variance, and the variance in the unselected population was higher between than within animals. Repeatability of live weight between 2 and 7 months was estimated to be 0.64 for males and 0.61 for females. In the selected population of females, repeatabilities were, after correction for the effect of selection, 0.32 (between 2 and 19 months) and 0.55 (between 7 and 19 months). Heritability for liveweight at seven months, around 0.4, was estimated from the regression of offspring on dam. Genetic gain in this trait was estimated to 1% per year.

INTRODUCTION

Reindeer *(Rangifer tarandus)* are managed in the northern parts of Fennoscandia with the main goal being meat production. The herding systems represent a unique animal husbandry endeavor, with many of the management demands differing from those of other livestock production systems. An important difference between intensive animal husbandry systems and reindeer husbandry is that in the former, environmental conditions can be more or less controlled, whereas in the latter they constitute a factor over which the herders have very little or no control. The meat yield in reindeer herding is determined by climatic variation, the degree of access to good pasture, stocking rate, level of migration between the winter and summer grazing areas, demographic structure and loss rates.

The reindeer herd is a natural unit in economic assessments where demographic and weight structures of the herd are more important components compared with parameters describing individual animal performance. Accordingly, management systems operate primarily on the herd level rather than on the animal level. Nevertheless, the boundary of the reindeer production system is the individual animal, where weight, survival and fertility influence on herd's performance. These factors are, in turn, subject to genetic and environmental variation. A further improvement in reindeer production could probably be achieved by selection of animals with a high potential for production.

Efforts to improve reindeer production through selection programs have been very limited. A shortcoming has been the lack of knowledge regarding individual performance. Also, under traditional reindeer herding conditions, the parents of an individual are unknown. Hence, the only selection efforts have been limited to choosing individuals on the basis on their own phenotypic value. However, in intensive systems with frequent recording on the individual level (Petersson et al., 1990), production parameters can be used as selection criterias. Replacement calves can be selected based on their own weight or on a combination of their weight and the productivity of their dam. Females can be culled based on their own predicted production. Growth rate of young reindeer, live weight of female yearlings, survival rates and fertility are important traits for an overall improved production in reindeer. Basic information is missing on means, variances, repeatabilities etc and has to be obtained before comparison of strategies can be made.

The objective of this work was to give estimates on the degree of repeatability of weights and on heritability of weight at 7 months of age in reindeer.

MATERIALS AND METHODS

This study is based on observations made in Tännäs Sami village located in the southern part of the reindeer area in Sweden (63°N, 12°E) (Petersson & Danell, 1993). Calf weights determined in connection with roundups in July (2 months of age) and November/December (7 months of age) were used. At the December weighings, only the calves needed for replacement were kept. Culling was based on a comparison of the observed weight with a threshold weight (Petersson et al., 1990): Calves with weights equal to or greater than the threshold were kept while the others were slaughtered. The females weighed at 19 months of age therefore constituted a selected group of animals.

The analyzed material was adjusted for various factors, such as days spent waiting in the main corral, and the scale used, as described by Petersson & Danell (1993). The model used to estimate the variance components was $Y^*_{ij} = \mu + f_i + u_j + e_{ij}$ where Y^*_{ij}=adjusted body weight; μ=mean; f_i=fixed effect of ith occasion, $i=1,2$; u_j=random effect of jth calf with mean=0 and variance = σ^2_u and e_{ij}=random residual effect with mean =0 and variance=σ^2_e

The analysis was done using Harvey's LSML76 program (Harvey,1977). The material was divided into subsets which were analyzed separately. There was one subset for each sex and year. The weight records were dealt with two at a time. For unselected male and female calves there was only one such pair: 2 and 7 months of age. For selected females there were three pairs: 2 and 7, 2 and 19 and 7 and 19 months of age. The correlation, $t = \sigma^2_u / (\sigma^2_u + \sigma^2_e)$, was computed from the estimated variances. To counterbalance the unequal variances of body weight between weighing occasions, analyses for estimating the repeatability were based on standardized observations.

According to Cochran (1954), the observed correlation between two variables is reduced after selection based on one of them is reduced. The reduction is proportional to the reduction in variance and the true correlation between the traits. The intra-class correlation or repeatability (t) is consequently also reduced as a result of culling at 7 months of age. An adjusted repeatability was thus calculated for each of the combinations of weights and was weighted based on the number of observations for each year.

There were 1457 cases in which dam-offspring weights at around 7 months of age were known. Hence, heritabilities could be estimated from the regression of offspring on dam (Falconer, 1983). The following model for analysis was used, $Y_{ij} = \mu + a_i + b_j + b_{OD}(X_{ij} - X) + e_{ij}$, where Y_{ij}=adjusted weights for the individual calf; μ=least-square mean; a_i=fixed effect of ith birth year of the dam; $i=1,..7$; b_j=fixed effect of jth birth year of the offspring $j=1,..6$; b_{OD}=regression coefficient for regression of son or daughter on dam for adjusted weight (X_{ij}) at 7 months. (X is mean weight calculated for each year separately) and e_{ij}=random residual effect. The GLM-procedure in the Statistical Analysis System (SAS,1985) was used in the analysis. Variances in the two sexes were equalized through adjustments made according to Falconer (1983).

The predicted response to the selection of replacement calves was obtained from $R=h^2 i\sigma_p$, (Falconer, 1983) for each sex separately, where i= the intensity of selection and σ_p =the phenotypic standard deviations for weight at selection. The intensity of selection was 1.30 and 0.83 for male and female calves, respectively. The phenotypic standard deviations for weight at 7 months of age were 4.74 and 4.30 for male and female calves respectively.

The generation interval in the male group in the study herd was approximated to two years since there is a considerable slaughter of males after their second rutting period. In the female group the generation interval was calculated to be 7.2 years. Thus, the yearly improvement in weight at 7 months of age due to the selection strategy applied in the herd was obtained by dividing the average selection response by the average generation interval.

RESULTS

Components of variance between and within calves as well as the repeatability figures are given in Table 1. For body weight the variance between calves was consistently greater than the variation within calves. In the selected females, variance components between and within animals as well as the repeatability figures between 2 and 7 and 7 and 19 months of age, respectively, are also given in Table 1.

In all data sets the adjusted repeatabilities (for the selection made at 7 months of age) were 8 to 25% higher than those computed as unadjusted estimates. The coefficient of variation for females at 2 months of age was 16% in the unselected and 12% in the selected group. At 7 months of age corresponding values were 11% and 8%.

Culling responses measured as differences in mean weight between groups of selected and slaughtered calves for both sexes are exemplified as a case study in Table 2. As can be seen, the mean weight in the selected groups was lower when the selection was made on 2-month weights. The observed differences between the mean weights of the selected and slaughtered groups are consistent with a theoretically computed response at 7 months of age. This would be expected in cases where the weights are normally distributed.

Table 1. Variation between (σ_u^2) and within calves (σ_e^2) and repeatability (*t*) of body weight.

Year	Males 2 to 7 months				Females 2 to 7 months				Females (selected) 2 to 19 months				7 to 19 months		
	N	σ_u^2	σ_e^2	$t^{**)}$	N	σ_u^2	σ_e^2	$t^{**)}$	N	σ_u^2	σ_e^2	$t^{***)}$	σ_u^2	σ_e^2	$t^{***)}$
1986	288	8.6	6.5	0.599	331	9.8	5.8	0.665							
1987	377	10.2	34.2	0.719	377	7.2	3.7	0.656	116	4.7	10.1	0.366	10.8	6.6	0.703
1988	538	8.7	5.4	0.626	556	7.4	5.1	0.602	145	4.6	12.2	0.308	10.0	9.6	0.596
1989	644	11.2	7.1	0.611	614	6.9	5.9	0.557	208	3.9	1.1	0.292	5.9	11.8	0.430
Mean*)		9.9	5.9	0.636		7.8	5.2	0.609		4.3	11.2	0.316	8.4	9.9	0.548

*) calculated as a weighted average. **) estimated on standardized variances. ***) calculated on standardized variances and adjusted for selection.

Table 2. Example of expected response, measured as the difference[1)] in mean weight (Δv) between selected and slaughtered groups, when weight-based selection of the calves was performed at 2 or 7 months of age

	Expected response[2)]		Observed response
	$\Delta v_{2\ months}$	$\Delta v_{7\ months}$	
Male	2.56	6.13	5.53
Female	1.42	3.57	3.24

1) The intensities of the selection were 1.295 for male calves and 0.830 for female calves. The standard deviations (kg), as given in Petersson & Danell (1993), at 2 months of age were 3.13 and 2.81 for the male and female calves respectively. Corresponding figures at 7 months of age were 4.74 and 4.30.
2) Repeatabilities (*t*) used in the expected response were .636 (males) and .609 (females) and one in the observed response .

Estimated heritabilities for 7-month weight were 0.38 (±0.09) and 0.40 (±0.10) for the males and females respectively. The response of 7-month weight to the selection was then 2.34 kg and 1.42 kg for the male and female paths respectively. Thus, the predicted genetic gain resulting from selection of the heaviest male and female calves for breeding is 0.41 kg, or about 1 % per year.

DISCUSSION

The repeatabilities were moderately high (0.316 to 0.609), indicating that the ranking of some of the animals changed between weighings. The repeatability values are expected to decrease over time, i.e. long-term estimates are more sensitive to environmental changes than are short-term estimates. This was also shown in the present study for the estimates, i.e. 0.316 vs. 0.548, between 2 to 19 and 7 to 19 months respectively, in the selected female group. Varo (1972) reported positive phenotypic correlations for both sexes between birth - and 7-month weights (0.46), birth - and 19-month weights (0.57) and 7 - and 19-month weights (0.57).

The computed selection differences in Table 2 shows that selection based on 2-month weights was inefficient. The average weight of calves in the slaughtered group increased and decreased in the selected group in comparison with observed data. Selection based on 7-month weight was almost twice as efficient. Thus, selection based on 7-month weight should be preferred when one of the goals is to increase the weight of replacement females.

The heritabilities are probably overestimated since maternal effects could not be separated and are therefore included in the h^2 estimates. Values based on offspring - grandmother records would give more unbiased estimates, but this type of analysis was not possible owing to a lack of information. The heritability estimates were probably low in young calves because environmental effects are large in the early life stage. In addition, it was not possible to correct the weights for age differences in the study herd: The earlier the animals were weighed the greater was the effects of confounding with date of birth or age at weighing. Variation in birth date contribute strongly to variation in weight. It was seen in the material that calf age affected July weights more than it affected weights measured on later dates, such as the studied trait (7-month weight or December weight).

Varo (1972) estimated the heritability coefficients for the progeny of the fathers according to the half-sib correlation. Estimates for weight the first autumn, 0.4 -0.6, were somewhat higher compared with the estimates in the study herd. These estimates agree well with corresponding estimates made on cattle breeds.

Live weight in reindeer is an important trait since it is strongly related to survival and female reproductive output (Petersson & Danell, 1993a). Increased live weight in calves at 7 months of age also has a direct economic benefit in systems where such calves are produced for slaughter. Theoretically, from a herd production point of view, increasing live weight on a long-term basis would give an overall higher herd output. On the other hand, selection aimed at improving productivity in reindeer is probably not as straightforward as in animal husbandry, where environmental conditions are fairly controlled. For example, over the long term, selection for rapid growth could decrease the ability to withstand severe environmental conditions, especially if there is a negative genetic correlation between growth rate and the ability to deposit the fat needed to survive the winter.

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