Fixed Effects And Heritability Of Embryo Recovery Rate In Horses

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Introduction

The improvement of reproductive traits is of great importance for horse breeders in terms of breeding and economic considerations, however the genetic improvement of (sport-) horses is mainly focused on jumping or dressage abilities.
Hinrichs (1993) found a recovery rate of 0.5 to 0.8 Embryos per cycle in young fertile mares. She reported that breed-dependent occurrence of multiple ovulations in the donor mare may increase the recovery rate. Squires (1999) figured out that the success of flushing is influenced by several factors: day of flushing, number of ovulations (ovulated oocytes), age and fertility of the donor mare as well as the quality (ability of fertilization) and the storage (fresh vs. frozen) of the semen. Based on a large data set, the objective of this study was to determine fixed effects affecting the success of flushing and to estimate the heritability for the reproduction trait "number of recovered embryos".

Material and methods

Records of reproduction traits for the years 2004 to 2008 were obtained from one stud farm in northern Germany. The records contained information of 718 warmblood donor mares. Data on reproduction (ovary and uterus control, inseminations and flushings) were registered daily by the veterinarians of the stud farm. Flushings were done 6 to 8 days after ovulation by flushing the uterus via cervix. These data were promptly stored on record sheets. The data acquisition at the stud farm occurred from the beginning of July 2008 to the end of April 2009. At that time there was the possibility to discuss non plausible data and to correct it in time. The analyzed reproduction trait was "number of recovered embryos". Totally, data of 5,708 flushings with 3,056 recovered embryos were recorded (Table 1). Because of small numbers of 2 to 4 embryos the trait was defined as a binary trait with no embryo vs. at least one embryo.

Table 1: Number of recovered embryos as proportion of positive flushings

Positive flushings	Number of recovered embryos	Number of embryos per flushing (in %)			
		1	2	3	4
2,773	2,773	90.4	9.1	0.5	0.04

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Significance of fixed effects was calculated using the GLIMMIX procedure of the SAS package (SAS, 2008) with a threshold mixed model and a probit link function:

$E[\pi_{ijkl}] = \Phi(Age_i + Season_j + TC_k + NOF_l + mare_m)$

where π_{ijkl} is the expected probability to recover at least one embryo, Φ is the cumulative probability function of standard normal distribution, Age_i is the fixed effect of i-th age (8 classes), $Season_j$ is the fixed effect of the j-th month of flushing (36 classes), TC_k is the fixed effect of the k-th preparation (6 classes), NOF_l is the fixed effect of the l-th number of flushing within season from March to September (9 classes) and $mare_m$ is the random effect of the m-th mare (718 animals).

The eight classes of donor age at flushing were defined as 2, 3, 4, 5, 6 to 8, 9 to 11, 12 to 15, ≥ 16 years old.

Treatment code represents six different combinations between time of treatment before insemination (last and second last treatment) and type of heat and ovulation inducing agents (Table 2). Treatment Code 3 was discarded due to a small number of observations (n = 30).

Table 2: Definition of Treatment Code (TC)

Last treatment	Second last treatment	TC
no	no	0
heat inducing agent	no	1
	heat inducing agent < 28 d	2
	heat inducing agent > 28 d	1
	ovulation inducing agent < 28 d	3
	ovulation inducing agent > 28 d	1
ovulation inducing agent	no	4
	heat inducing agent < 28 d	5
	heat inducing agent > 28 d	4
	ovulation inducing agent < 28 d	6
	ovulation inducing agent > 28 d	4

For estimation of heritability of recovery rate the random effect of the mare was divided into the permanent environmental effect of the donor mare and the additive genetic effect of the animal. The Pedigree contained four generations back (totally 3,692 animals in pedigree); number of sires was 188 with 3.8 daughters on average.

Using a Bayesian approach the estimation of variance components for recovered embryos was done with the Gibbs sampling algorithm implemented in the LMMG_TH program, a threshold model modification of LMMG (Reinsch, 1996). Mean values of the posterior distributions are reported as parameter estimates. For the trait 220,000 cycles were generated and the result of each cycle retained. Convergence was determined by visual inspection. The results of the first 20,000 iterations were discarded (burn-in) and the results of the remaining 200,000 iterations were used for calculation of variance component estimates.

Results and discussion

The number of recovered embryos per flushing was 0.54 over all years (2004 to 2008) and all donor mares (718 mares). This value is in agreement with Hinrichs (1993) who reported probabilities to flush an embryo ranging from 0.5 to 0.8 in young fertile mares.

Fixed effects of age, season and preparation of the mare but not the number of flushing had a significant influence on the recovery rate.
The age of the mare at time of flushing is an important influencing factor. At the age from 2 to 6 years, minor differences were detected to recover an embryo (0.44 to 0.46). With the increasing of the mare's age, the probability to recover an embryo decreases to 0.29. Regarding the season of flushing, the probability to recover an embryo was higher in spring and early summer than in late summer and autumn. But there is no clear trend between the years.

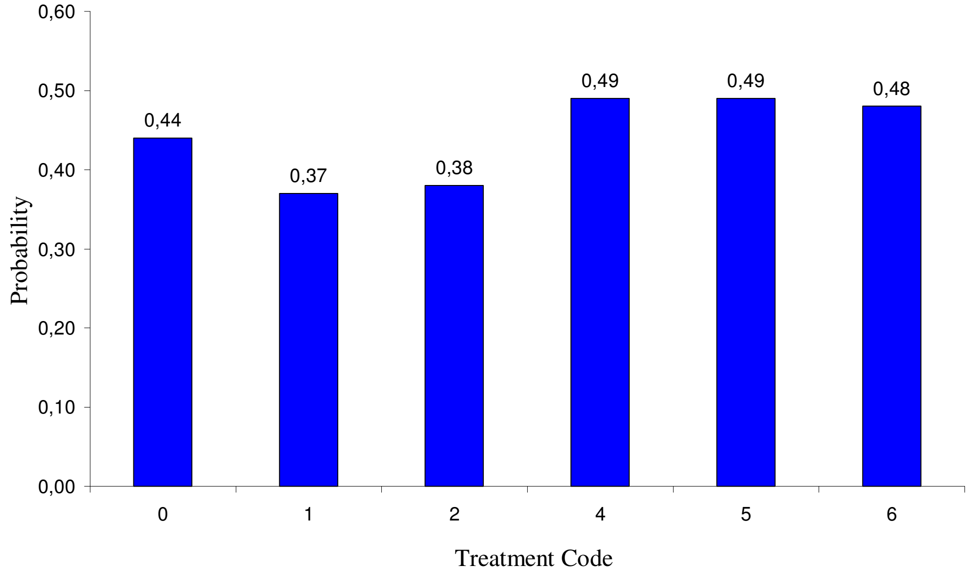

Figure 1: Influence of treatment before insemination on probability of successful flushing (LS-means)

As shown in Figure 1, preparation of the mare has an influence on recovery rate, too. Application of an ovulation inducing agent with or without previous application of heat inducing agents increases the success of flushing.

There are genetic differences between donor mares. The distribution of the mean heritability for the number of recovered embryos is shown in Figure 2. As expected for fertility parameters the heritability was low ($h^2 = 0.046 \pm 0.016$). Due to the low heritability on the one hand and to the breeding goals for sport horses that are mainly focused at the improvement of performance in dressage and jumping competition and not increasing fertility of mares on the other hand, it would be more appropiate to improve the flushing management (age of the mare, season, preparation). As shown above, there are possibilities to increase the number of recovered embryos.

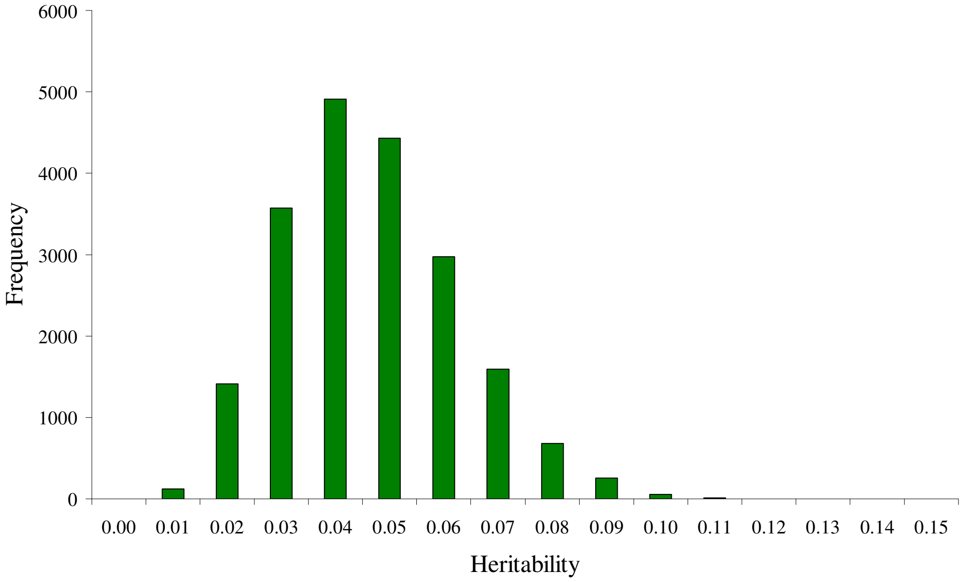

Figure 2: Distribution of estimated heritability of embryo recovery rate

Conclusion

In this study we showed that there are differences in the number of recovered embryos between donor mares. Age, season and preparation had a significant influence on recovery rate, giving the opportunity to improve the management for increasing the embryo recovery rate. As expected for reproduction traits the heritability for recovery rate is low, restricting the practical use for breeding.

Further investigations will include the pregnancy rate of the recipients and the number of foals born alive to describe embryonic fitness and to determine factors affecting the embryo/foal in the recipient.

References

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