Analysis of fertility in canine populations in respect to genetic and environmental influences

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Introduction

Reproduction is a multifactorial trait. The final litter size in multiparous species depends on ovulation rate, ova success, uterine capacity and embryonic survival. *Ribero et al*.(1997) studied littersize in mice as a model animal in respect to the base components. They compared simulation data with experimental results. Uterine capacity was an important source of variation but ovulation rate was the more limiting component. Response to experimental selection (heritability) was 0.15 for litter size. *Satoh et al.* (1997) report about 15 generation selection in golden hamsters as a model animal for pigs. They got 2.2 pups more in the selection line. Heritability was found to be 0.10 for litter size. In these cases, as usual, litter size was treated as phenotypic realisation of the mother. A male effect can come from embryonic survival and from semen quality. This was mainly investigated in context with semen trading and insemination programs in pigs. *Smital et al*.(2005) found high heritabilities for semen quality criteria (Volume 0.58, sperm concentration 0.34, progressive motion 0.38), but the heritability of the target trait, litter size, was only 0.05. The male genetic effect on conception was 0.29.

Similar investigations were presented by *Grandjot* (1996). He analysed the data from a pig hybrid program over 6 years with 36628 matings. He found like *Smital et al*., under the given semen confection, no influence of the semen parameters. The influence of the boars on conception and litter size was so low that selection based on their own fertility results did not promise acceptable success. Heritability for the male influence was 0.010 and for the female 0.084. The genetic influence on conception was 0.003 from the male and 0.033 from the female part.

Objective of the work

Fertility is a key parameter in animal breeding. Reproduction rate is of iterest 1. as an indicator for genetic fitness, 2. as a parameter for selection potential for other (health or performance) traits and 3. as an economic factor for the breeder. Although these factors are of high importance, most breed clubs don't breed actively for fertility. There are good arguments for that, because breeders observe, that the reproduction rate (littersize) is changing for the same bitch from year to year, which makes classical selection difficult. Further more reproduction is a selfregulating trait, because unfertile bitches don't reproduce and those with high number of offspring have a higher chance to produce breeding dogs. Litter size has an optimum for the specific breed, which means, that simple breeding for more puppies may be contraproductive in some way. This investigation is looking for the level of reproduction in different canine breeds, the synergy of male and female influences and the genetic background.

Material and methods

Data were taken from a sample of breeds, stored in the Computer Center for Animal Breeding and Applied Genetics. These data come from the official registrations in the studbook database. For all breeds the number of whelps born alive and dead and the puerperial losses were available, in some breeds up to 25 years backward. The ID of the bitch and the male mate with their complete pedigrees allowed to analyse genetic variance as well for male as for female genetic disposition. Variance components were estimated using a Restricted Maximum Likelihood (REML) approach. Heritability is defined as the genetic component in relation to

the total variance (genetic plus nongenetic factors). The permanent environmental conditions of the kennel, the experience of the breeder (1., 2., 3. etc. litter), age of the bitch, month and year of birth were treated as environmental effects.

Results and discussion

The level of reproduction differs from breed to breed. There is a tendency, that litter size is increasing with the bodysize of the breed. Bergér des Pyrénées show in this sample of breeds the lowest value with 3.94 (1-7) whelps born and 0.22 (0-6) dead. On the other side Kromfohrländer, a breed of similar size, has an average of 6.36 (1-13) with 5.85 finally registerd whelps (1-11). The giant breeds (St. Bernhard, 7.63 born (1-16), 5.30 registered (1-16) or Landseer, 8.07 born (1-16), 6.83 registered (1-13)) show much more variation and higher rate of dead whelps. An overview is given in Table 1. The registered dogs are those born minus the dead puppies at birth minus the early losses up to 8 weeks. The difference is about 10%, but remarkable is the St.Bernhards dog with a reduction from 7.64 to 5.31 (31%) or Landseer from 8.07 to 6.83 (15%).

Table 1: Level of reproduction in different breeds (n=41249)

Breed	Whelps born	Born dead	Registered	N
Berger des Pyrénées	3.94 (1-7)	0.22 (0-6)	3.73 (1-7)	619
Deutscher Jagdterrier	5.68 (1-13)	0,56 (0-12)	5,11 (1-12)	7422
Hovawart	7.48 (1-15)	0.58 (0-11)	6.84 (1-15)	3723
St. Bernhard Dog	7.64 (1-19)	2.24 (0-16)	5.31 (1-16)	1396
Beagle	5.41 (1-13)	0,30 (0-7)	5.02 (1-13)	2269
Kromfohrländer	6.36 (1-13)	0.29 (0-4)	5.85 (1-11)	495
Labrador Retriever	7.17 (1-14)	0.60 (0-8)	6.40 (1-14)	8161
Landseer	8.07 (1-16)	1.32 (0-6)	6.83 (1-13)	229
Rottweiler	6,77 (1-18)	1,26 (0-16)	5,28 (1-14)	8873
Kleiner Münsterländer	7,37 (1-16)	0,47 (0-12)	6,90 (1-15)	4458
Deutscher Wachtelhund	7,12 (1-16)	0,89 (0-14)	5,90 (1-14)	2858
Alaskan Malamute	5.94 (1-11)	0,21 (0-7)	5,57 (0-11)	155
Samojede	6.34 (1-11)	0,68 (0-8)	5,43 (0-11)	151
Siberian Husky	5.31 (1-12)	0.13 (0-7)	5,07 (0-12)	440

Fig.1 Distribution of litter size in Labrador Retriever

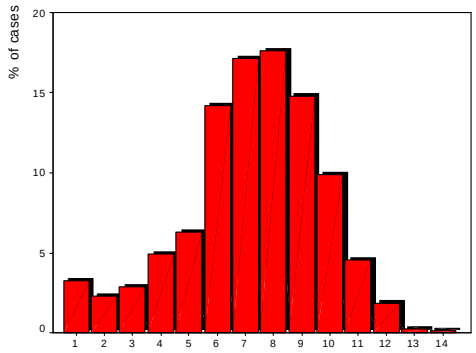
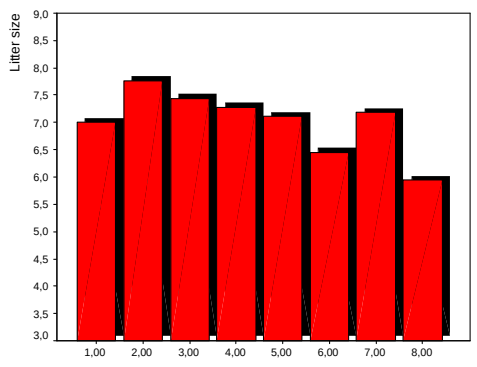


Fig.2 Effect of age on litter size in Labrador Retriever bitches



The pattern of variation is nearly equal in all breeds. As an example the results from Labrador Retriever are given in Fig.1. The distribution is “normal” with a slight overrepresentation of the lowest classes, which can also be seen in nearly all other breeds. Fig. 2 shows the influence of the bitchs’ age, which is limited to 8 years by the breeding rules.

There are significant seasonal influences, with a bimodal pattern, with low values in January and September. The average year effect on litter size is shown in Fig. 3 and on conception rate in Fig. 4.

Fig.3 Year effect on litter size in Labrador Retriever bitches

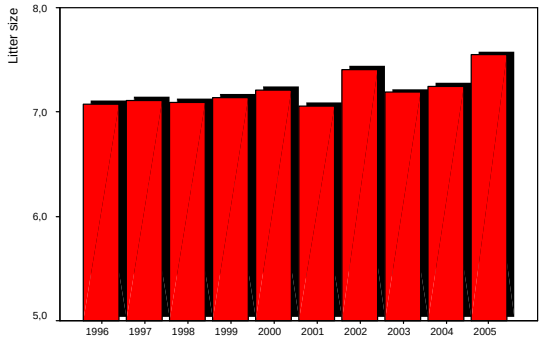
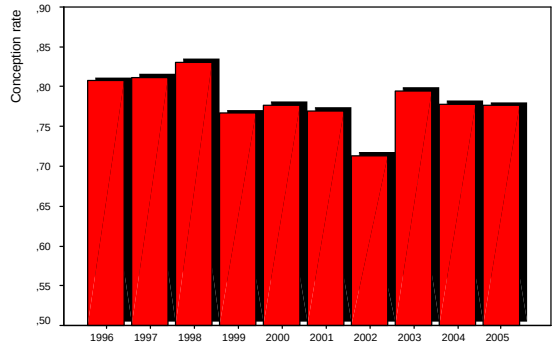


Fig.4 Year effect on conception rate in Labrador Retriever bitches



Heritability was found to be various between breeds, depending on the total variance in the population. The values range from low values in the nordic breeds Alaskan Malamute and Samojede, represented by low number of observations, up to high heritability of 0.41 in Kromfohrländer. The results are shown in Table 2. The permanent maternal environmental effect is that part coming from the bitch which can not be explained by the familial, genetic, linespecific level of reproduction. Genetic and permanet environmental effect both togeter quantify the maternal influence on litter size. The influence of the male partner on litter size was near zero in nearly all breeds.

Table 2: Influence of the bitch and the male mate on litter size

Breed	**Heritability**	**Permanent mat. environment**	**Effect of the male mate**	**Residual Effects**
Berger des Pyrénées	**0.273**	**0.089**	**0.003**	**0.635**
Deutscher Jagdterrier	**0.145**	**0.263**	**0.076**	**0.517**
Hovawart	**0.144**	**0.153**	**0.005**	**0.697**
St. Bernhard Dog	**0.156**	**0.082**	**0.000**	**0.762**
Beagle	**0.305**	**0.066**	**0.008**	**0.621**
Kromfohrländer	**0.415**	**0.119**	**0.036**	**0.431**
Labrador Retriever	**0.102**	**0.027**	**0.031**	**0.840**
Landseer	**0.174**	**0.199**	**0.042**	**0.585**
Rottweiler	**0.124**	**0.105**	**0.017**	**0.754**
Kleiner Münsterländer	**0.185**	**0.106**	**0.025**	**0.685**
Deutscher Wachtelhund	**0.237**	**0.075**	**0.014**	**0.675**
Alaskan Malamute	**0.073**	**0.097**	**0.202**	**0.628**
Samojede	**0.000**	**0.303**	**0.078**	**0.619**
Siberian Husky	**0.104**	**0,183**	**0.098**	**0.615**

The studbook registration forms are sent from the most breed offices to the computer center when a litter is born. Only in some breeds the mating data are stored in the database and only in that breeds information about conceptions are available. Table 3 shows the separation of genetic male influence, the environmental permanent influence and the summerized influence of the bitch on mating success in that specific breeds. Trusting the results from that breeds

with a huge ammount of data (Labrador, Rottweiler), the genetic male effect is neglectable and a permanent nongenetic effect is low. 13 to 25% of the variance is caused by the bitch, partly by it's genotype, partly by the specific environment. So, most of the variance is caused by random influences, changing from mating to mating.

Table 3: Quantification of the influence of the male dog and the bitch on conception

Breed	Male dog's genotype	Male dog's permanent environment	Genotype of the bitch	Permanent environment of the bitch
Alaskan Malamute	**0.000**	**0.207**	**0.073**	**0.097**
Samojede	**0.000**	**0.078**	**0.000**	**0.303**
Siberian Husky	**0.121**	**0.000**	**0.104**	**0.183**
Labrador Retriever	**0.000**	**0.036**	**0.102**	**0.027**
Rottweiler	**0.013**	**0.024**	**0.142**	**0.108**

Conclusions

It could be found, that a valid genetic variation exists within most breeds for litter size which allows to detect and differ high and low fertile lines. The individual disposition for reproduction can be evaluated by using information from the bitch and/or all its female relatives under reproduction. These breeding values are also estimable for male dogs from records of mother, sisters, daughters etc. They can be used for strategic mating to upgrade the breed or for compensatoric mating due to an optimum. Breeding goals can be defined in different way. To breed for the number of raised pups can not be satisfying, if this is combined with higher losses. Mating sires and dams in respect to the genetic expectation for daughters optimal litter size would be, together with selection against losses, the better way.

Summary

More then 41 thousend litters from 14 dog breeds were analysed in respect to genetic or environmental influences on reproduction traits. Litter size is mainly influenced by the bitch. Heritability was found up to 41%. Conception rate was more influenced by the bitch's disposition than by that of the male dogs. Heritability was near zero and individual environmental disposition was between 2 and 4% for males. Breeding should focus on the maternal disposition.

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