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The use of a behaviour test for selection of dogs for service and breeding. II. Heritability for tested parameters and effect of selection based on service dog characteristics

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Abstract

Heritability calculated for characteristics evaluated in behavioural tests can be used as a tool to select different kinds of service dogs. The evaluation was based on the test results of 1310 German shepherds and 797 Labrador retrievers. The heritability for all evaluated characteristics of the two breeds was significantly different from zero with the exception of the characteristic prey drive in Labrador retrievers.

The test results for each characteristic were summarised to form an index value which simplified the interpretation of the test results. The heritability for this index value was 0.24 for both German shepherds and Labrador retrievers, a value that must be considered high as it included all tested parameters. The heritability was also calculated for the four factors derived from a factor analysis of the test results. Heritability estimates for these four factors were 0.15 to 0.32.

The results show that complex behavioural patterns in dogs can be subjectively evaluated by an experienced person and that no more than a few characteristics are needed in order to describe the differences between dogs.

Breeding results in a German shepherd population at the Swedish Dog Training Centre (SDTC) improved a relatively short time after the initiation of basing the selection of breeding animals on the index value of each individual animal. German shepherds bred by the SDTC also had higher index values than privately bred dogs which shows the importance of a goal-oriented breeding programme with emphasis on service dog characteristics.

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Finally different ways in which to collect information about dog behaviour are discussed. It is suggested that a subjective evaluation of certain behaviour characteristics is preferred to a factual description of reactions. © 1997 Elsevier Science B.V.

Keywords: Dog; German shepherd; Labrador retriever; Genetics; Heritability; Selection; Service dog; Temperament test

1. Introduction

There are several reports on heritability variations of quantitative behaviour patterns in dogs. The most comprehensive study is by Scott and Fuller (1965) at Bar Harbor showing significant hereditary-dependent variations in five medium-sized breeds of dog. They also found considerable maternal effect on the test results of young dogs. The tests performed in Scott and Fuller's studies, however, were not aimed at the selection of different types of working dog.

Tests to select dogs for work or breeding are reported in several studies. Some studies show remarkably high heritabilities. Goddard and Beilharz (1982) found a heritability of 0.44 for the characteristic "success" when testing the suitability of dogs to become guide dogs for the blind. No strong maternal effect was found on these tests performed on mature dogs. In another paper (Goddard and Beilharz, 1982/83) they estimated heritability of fearfulness to be 0.5. Bartlett (1976, cited from Mackenzie et al., 1986) found moderate and low heritability for guide-dog characteristics tested on different breeds. The maternal effects were considered low. In another testing programme for guide dogs performed on puppies 8–12 weeks of age (Scott and Bielfelt, 1976), medium to low heritability was found for tested traits with high maternal effects on the results.

Mackenzie et al. (1985) show a heritability of 0.51 for the characteristic "temperament" in a study of suitability tests for military dogs. Reuterwall and Ryman (1973) on the contrary show a low degree of genetic variation when evaluating suitability tests for working dogs.

There is so far no report on breed differences in dogs tested in a similar testing procedure. In addition there is little published about how a dog population reacts to selection based on tested characteristics.

The aim of this study was to evaluate whether variation in test results at the Swedish Dog Training Centre (SDTC) were hereditary with regards to tested characteristics, calculated index value and/or the four factors from a factor analysis. The aim of this study was also to study the effect of a structured breeding programme aiming to enhance the working characteristics of service dogs.

2. Material and methods

Heritability analysis and comparison of test results of SDTC-bred and privately bred dogs were made on the same material as in Study I, i.e. the test results of 1310 German shepherds and 797 Labrador retrievers (Wilsson and Sundgren, 1996). Of these 1469

(1002 German shepherds and 467 Labrador retrievers) were bred by the SDTC during the years 1983–1991 while 637 (308 German shepherds and 330 Labrador retrievers) were purchased from private breeders at the age of 8 weeks. All pups were placed in private homes at 8 weeks of age and behaviour tested at 450–600 days of age. A detailed account for this is given in the report by Wilsson and Sundgren (1996).

A factor analysis was performed on the same material using the actual test results with no derivation of partial index values giving four factors explaining 75% of the variation. The factors were subjectively named: (1) mental stability, (2) willingness to please, (3) affability (ardour for Labrador retrievers), (4) ardour (affability for Labrador retrievers). A detailed description of the factor analysis is presented by Wilsson and Sundgren (1996). For all calculations a standard program for computerised analysis, StatView v. 4.0, was used.

Heritabilities were estimated from intraclass correlation between sibs within groups of full and half sibs and are based on the combined components of sire and dam variance. Calculations were made in accordance with formulas given by Becker (1985) for treatment of unbalanced data, i.e. variable sizes of progeny groups both for sires and dams.

The breeding results during a period of 12 years at the SDTC were analysed based on age-corrected index values of 1112 male German shepherds, i.e. all German shepherd males tested from the kennel during the 12-year period. The age correction of the index values was made because several of the males were tested at a relatively young age, less than 450 days of age, when the effect of age was found to be of great importance for the test results (Wilsson and Sundgren, 1996).

From the year 1986, a new criterion for selection of breeding animals was introduced. The breeding animals were recruited from litters where the mean index value was higher than average. Only individuals with the highest index values were selected but no more than one male and two females from each litter. All older breeding animals not fulfilling this criterion were excluded.

No single male was allowed more than 70 offspring. The mean index value of the selected breeding animals after 1986 ranged from 14.0 to 14.3. The number of breeding females of the breed German shepherd varied from 25 to 50 animals.

3. Results

3.1. Analysis of heritability

Table 1 shows that all values of heritability, except that for the characteristic prey drive in Labrador retrievers, are significantly different from zero. In German shepherds the highest heritability was achieved for the characteristic affability ($h^2 = 0.37$) and the lowest for sharpness ($h^2 = 0.13$). For Labrador retrievers the highest heritability was found for ability to co-operate ($h^2 = 0.35$) while that for prey drive was lowest ($h^2 = 0.05$). No strong maternal effects on the test result were found.

Table 2 shows heritability estimates for the calculated index value which in both breeds was 0.24.

Table 1
Heritability estimates and standard error for different mental characteristics calculated for 1310 German shepherds and 797 Labrador retrievers. The analysis is made on the combined variance components for sire and dam

Characteristic	German shepherds	Labrador retrievers
Courage	0.26 ± 0.06	0.28 ± 0.09
Sharpness	0.13 ± 0.05	0.11 ± 0.07
Defence drive	0.20 ± 0.06	0.22 ± 0.08
Prey drive	0.31 ± 0.07	0.05 ± 0.07
Nerve stability	0.25 ± 0.06	0.17 ± 0.08
Temperament	0.15 ± 0.05	0.10 ± 0.07
Hardness	0.15 ± 0.05	0.20 ± 0.08
Affability	0.37 ± 0.08	0.15 ± 0.07
Abil. to co-operate	0.28 ± 0.07	0.35 ± 0.09

The four factors obtained in the factor analysis have been considered new characteristics. Table 3 shows that the heritability for the four factors from the factor analysis ranged from 0.17 to 0.32 for German shepherds and 0.15 to 0.29 for Labrador retrievers.

3.2. Changes in population due to selection

Fig. 1 shows changes in index value for dogs bred at the SDTC during the time period 1979–1990. In the period 1979–1986, the index value decreased by two units probably due to the fact that there was no selection for behavioural characteristics. After the new criteria for selection of breeding animals were introduced the index value for male German shepherds increased from about 8 to about 9 in 4 years.

3.3. Comparison of SDTC-bred and privately bred dogs

Table 4 shows the mean partial index values for the different test situations of male German shepherds bred by the SDTC, those that were privately bred and the difference between the two populations. Male German shepherds from the SDTC had significantly higher partial index values for all characteristics except sharpness. Male German shepherds from the SDTC had an average index value of 9.47 which is 2.04 units higher than the average of privately bred dogs (7.43). Table 4 also shows that the sub-index value for the 126 dogs sold as police dogs were scored higher than the average for all characteristics compared both with SDTC-bred and privately bred dogs.

Table 2
Heritability estimates and standard error of the index value calculated for 1310 German shepherds and 797 Labrador retrievers

	German shepherds	Labrador retrievers
Females	0.27 ± 0.11	0.15 ± 0.12
Males	0.33 ± 0.10	0.50 ± 0.17
Both sexes	0.24 ± 0.06	0.24 ± 0.06

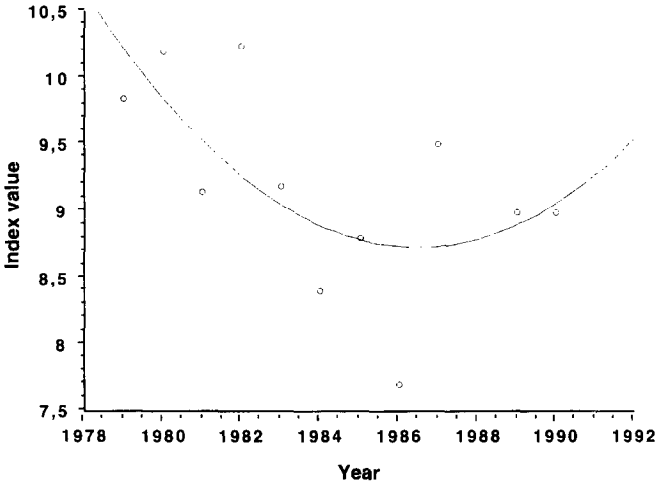

Fig. 1. Change of index value of the dog population at the SDTC, 1979–1990. Based on the mean index value in 1112 male German shepherds.

Table 3
Heritability estimates and standard error of the four factors from the factor analysis

	German shepherds	Labrador retrievers
Factor 1	0.25 ± 0.06	0.29 ± 0.09
Factor 2	0.24 ± 0.06	0.20 ± 0.08
Factor 3	0.32 ± 0.07	0.15 ± 0.07
Factor 4	0.17 ± 0.06	0.22 ± 0.08

Table 4
Partial index values for male German shepherds. Mean values for dogs purchased from private breeders, bred by the SDTC and for dogs recruited as police dogs

Characteristic	Private ($n = 227$)	SDTC ($n = 502$)	Police ($n = 126$)	Difference SDTC − private
Courage	0.80	1.02	1.68	0.22[a]
Sharpness	0.97	0.98	1.13	0.01 (NS)
Defence drive	0.72	1.07	1.97	0.35[a]
Prey drive	0.81	0.95	1.50	0.14[a]
Nerve stability	0.70	1.15	1.76	0.45[a]
Temperament	0.90	0.97	1.03	0.07[a]
Hardness	0.78	1.11	1.76	0.33[a]
Affability	0.87	1.14	1.22	0.27[a]
Co-operation	0.84	1.04	1.26	0.20[a]
Index value	7.43	9.47	13.37	2.04[a]

[a]Indicates significance of $P < 0.05$.
NS, not significant.

4. Discussion

The heritability for the different characteristics were 0.05–0.37 (Table 1). There are small differences between breeds and in most cases the difference is not statistically significant.

It is remarkable that the heritability for the calculated index value and for the four factors from the factor analysis is comparatively high (Tables 2 and 3). This is normally expected to hold true for single well-defined characteristics. This study, however, shows a higher heritability for complex behaviour systems. The more complex parameters, index values and the four factors from the factor analysis show a higher heritability than most of the single characteristics that they are based on. One possible explanation is that the evaluated characteristics overlap and a higher degree of confidence can be achieved if the information from the evaluated characteristics are pooled. The probability of this explanation is further enhanced by the relatively high positive phenotypic correlation maintained between the characteristics (Wilsson and Sundgren, 1996). Goddard and Beilharz (1982) show a heritability as high as 0.44 to predict a dog's ability to become a guide dog for the blind. The characteristic used was defined as "success". Mackenzie et al. (1985) calculated the heritability of "temperament" to be 0.51 in 575 military dogs. In both cases the high heritability figures were calculated on a characteristic that summarises complex behaviour systems. With regards to this, it should be pointed out that the characteristic "temperament" in the study of Mackenzie et al. (1985) is defined as a military dog's suitability for protection and tracking and must not be considered synonymous with the definition of temperament used in this study.

Reuterwall and Ryman (1973) showed comparatively low heritability in a study based on behaviour tests similar to those in this study. Reuterwall and Ryman (1973) suggest that this is due to previous selection which has left little additive genetic variance in the population. A more plausible explanation could be that they have not considered the age differences in the dogs. A previous pilot study at the SDTC show that the index value increased 0.3 for each month on average in a group of dogs tested in the age range of 300–730 days. It was later shown (Wilsson and Sundgren, 1996) that the effect of age is negligible within the age interval of 450–600 days.

In the Reuterwall and Ryman (1973) study, the dogs were tested by different people (personal information regarding testing routines at the SDTC during that period) which adds an environmental variance component. This suggests that it is most important to keep the number of people evaluating the dogs' behaviour down to a minimum and to have routines that regularly coordinate the standard of those people.

Alternatively one could make repetitive tests or have two or more people make their independent evaluations of each occasion.

Subjective evaluation of behaviour characteristics may have some advantages. The characteristic nerve stability is the most complex behaviour system included in this study and it is based on the subjective evaluation of the dog's reaction in all of the test situations. The definition of this characteristic might seem unclear to those not working in the field but to experienced judges of dog behaviour the definition is clear. It is also common knowledge among experienced dog handlers and trainers that this characteristic is one of the most important in any kind of service dog. The comparatively high

heritability of 0.25 (German shepherds) also shows that an experienced judge is able to perform a reliable subjective evaluation of this characteristic. The characteristic nerve stability would have been hard to estimate only from a description of how a dog reacted in a certain test situation.

The results also show one other important aspect with regards to behaviour testing for selection of breeding animals. It is not merely the test in itself that is important in obtaining meaningful information; just as important is how the information is treated and interpreted. One way to do this, by the use of a factor analysis, is to calculate new factors and based on these create a new nomenclature, as suggested by Goddard and Beilharz (1984). One other method is to create an interpretation template based on the knowledge of the test and training results of a large group of dogs, as in the calculation of the index value. Methods like these not only make it easier to summarise the results from several different test situations, but they also simplify the interpretation of the results with regard to breed, sex or different areas of use.

References

Bartlett, C.R., 1976. Heritabilities and genetic correlation between hip dysplasia and temperament traits of seeing-eye dogs. Masters Thesis, Rutgers University, New Brunswick, NJ.

Becker, W.A., 1985. Manual of Quantitative Genetics. Academic Enterprises. Washington State University, p. 190.

Goddard, M.E. and Beilharz, R.G., 1982. Genetic and environmental factors affecting the suitability of dogs as guide dogs for the blind. Theor. Appl. Genet., 62: 97–102.

Goddard, M.E. and Beilharz, R.G., 1982/83. Genetics of traits which determine the suitability of dogs as guide-dogs for the blind. Appl. Anim. Ethol., 9: 299–315.

Goddard, M.E. and Beilharz, R.G., 1984. A factor analysis of fearfulness in potential guide dogs. Appl. Anim. Behav. Sci., 12: 253–265.

Mackenzie, S.A., Oltenacu, E.A.B. and Leighton, E., 1985. Heritability estimate for temperament scores in German shepherd Dogs and its genetic correlation with hip dysplasia. Behav. Genet., 15: 475–482.

Mackenzie, S.A., Oltenacu, E.A.B. and Houpt, K.A., 1986. Canine behavioral genetics – a review. Appl. Anim. Behav. Sci., 15: 365–393.

Reuterwall, C. and Ryman, N., 1973. An estimate of the magnitude of additive genetic variation of some mental characters in Alsatian dogs. Hereditas., 73: 277–284.

Scott, J.P and Bielfelt, S.W., 1976. Analysing the puppy-testing program. In: J.P. Scott, J.L. Fuller, B.E. Ginsburg and S.W. Bielfelt (Editors), Guide Dogs for the Blind: Their Selection, Development, and Training. Elsevier, Amsterdam, pp. 39–76.

Scott, J.P. and Fuller, J.L., 1965. Genetics and the Social Behaviour of the Dog. Univ. of Chicago Press, Chicago.

Wilsson, E. and Sundgren, P.-E., 1996. The use of a behaviour test for selection of dogs for service and breeding. I. Method of testing and evaluating test results in the adult dog, demands on different kinds of service dogs, sex and breed differences. Appl. Anim. Behav. Sci., 53: 279–295.