ELSEVIER

Preventive Veterinary Medicine 63 (2004) 39–50

PREVENTIVE VETERINARY MEDICINE

www.elsevier.com/locate/prevetmed

The use of a genetic-counselling program by Dutch breeders for four hereditary health problems in boxer dogs

Marjan A.E. van Hagen [a,*], Luc L.G. Janss [b], Jan van den Broek [c], Bart W. Knol [a]

[a] *Department of Clinical Sciences of Companion Animals, Faculty of Veterinary Medicine, Utrecht University, P.O. Box 80154, 3508 TD Utrecht, The Netherlands*

[b] *Institute for Animal Science and Health, ID-Lelystad, P.O. Box 62, 8200 AB Lelystad, The Netherlands*

[c] *Faculty of Veterinary Medicine, Centre of Biostatistics, Utrecht University, P.O. Box 80154, 3508 TD Utrecht, The Netherlands*

Received 14 June 2003; received in revised form 22 December 2003; accepted 19 January 2004

Abstract

Our group developed a genetic-counselling program for boxer-dog breeders in The Netherlands, using data for cryptorchidism (uni- and/or bilateral), epilepsy, knee-problems (including ligament rupture, fractured or ruptured meniscus, severe osteo-arthrosis of the knee, or a combination of these disorders), and schisis (including cheiloschisis, palatoschisis, or cheilopalatoschisis). We transformed the estimated breeding values (EBVs) into odds ratios (ORs), to enable the breeder to compare the risk for each of the traits for a certain dam–sire combination with the average population risk (set at 1). The goal of the study was to evaluate the use of our genetic-counselling program by Dutch breeders of boxer dogs.

We asked breeders of the Dutch Boxer Club to send in an application form for genetic-counselling from June 1 to December 1, 2000. Breeders indicated on this application form three desirable sires for their dam (sire 1, sire 2, sire 3) in random order. On the basis of this information, a counselling report was produced which included ORs for the four diseases in litters of the dam–sire combinations indicated on the application form. Together with the counselling report, the breeders received an evaluation form.

We received 129 application forms from 70 breeders, and collected 125 evaluations. Of these evaluations, 96 were informative about the influence of the counselling report on sire choice. The most-important criteria used by breeders to select sires were: the exterior characteristics (60%) and known progeny (52%). Although it was the first time breeders could make use of genetic-counselling,

* Corresponding author. Tel.: +31-302539175; fax: +31-302518126.
E-mail address: m.a.e.vanhagen@vet.uu.nl (M.A.E. van Hagen).

0167-5877/$ – see front matter
doi:10.1016/j.prevetmed.2004.01.007

32% of the breeders indicated that the genetic-counselling played a major role in their sire selection. Breeders expressed little difference in importance for the four genetic traits, but there was a tendency to consider epilepsy more than the others.

Breeders hesitated to put long-term population interest above short-term personal interest. Nevertheless, the general conclusion of this study is that breeders acknowledge the value of counselling, especially to reduce the frequency of a threatening disease such as epilepsy.

Keywords: Genetic-counselling; Odds ratios; Breeders; Boxer dog

1. Introduction

Genetic-counselling could provide a service in the prevention of inherited disease in dog populations. This, however, requires individual motivation and concerted cooperation by breeders (Willis, 1989; Brass, 1989). Genetic-counselling programs of different types have been set up to help dog breeders decrease the frequency of health problems (Brass, 1989; Famula and Oberbauer, 1998; Hall and Wallace, 1996; Hedhammer, 1991; Leppanen and Saloniemi, 1999; Patterson, 1993; Swenson et al., 1997). Livestock breeders have been using estimated breeding values (EBVs) successfully both to change many polygenetic traits in livestock species (such as behaviour, appearance, and production rates) and to select against genetic defects. These EBVs were introduced only recently as a tool to reduce health problems in dog populations (Leighton, 1999; Leppanen et al., 2000; Lingaas and Klemetsdal, 1990). In the future, veterinarians will be able to offer an increasing number of DNA-tests to their clients (Ostrander et al., 1993; van Oost, 1998). This will improve the counselling opportunities for monogenetic traits (especially, for recessive and late-onset dominant diseases). Because this DNA-testing is not sufficiently available yet, the elimination of genetic disease is hampered (Smith, 1994). In the meantime, non-DNA-based genetic-counselling can prevent spreading of hereditary disease in pure-bred dog populations.

Our group developed a genetic-counselling program for boxer-dog breeders in The Netherlands. We used data for cryptorchidism, epilepsy, knee-problems, and schisis. Dog breeders are not experienced in dealing with EBVs, therefore the interpretation of the EBVs for several health traits in one report was expected to be very difficult for them. To reduce this problem, we transformed the EBVs for the breeders into odds ratios (ORs). We did not rank the ORs of the four disease traits on the counselling report (CR); in selecting a dam–sire combination, the breeder could make his own choice in using both the CR and the more-traditional criteria according to his own insight.

Knowledge about the breeder's acceptance of EBVs and the effect of counselling is still poor. To understand why breeders choose a certain dam–sire combination, we studied: (1) how a CR was used by the breeders compared to the traditional criteria for choosing a dam–sire combination, (2) whether or not breeders ranked the four genetic traits, and (3) whether or not there was a relation between the value of the computed ORs and the dam–sire combination of choice.

2. Materials and methods

2.1. Traits

We decided to counsel for cryptorchidism (uni- and/or bilateral), epilepsy, knee-problems (including ligament rupture, fractured or ruptured meniscus, severe osteo-arthrosis of the knee, or a combination of these disorders) and (facial) schisis (including cheiloschisis, palatoschisis, or cheilopalatoschisis). Heritability is an important predictor of the success of selection, because heritability expresses the reliability of the phenotypic value as a guide to the breeding value (Falconer and Mackay, 1996). Our research group performs a genetic-epidemiological follow up study of a birth cohort of boxer dogs 1994–1995, which will be continued up to 2004 by written questionnaires. This study has revealed a wealth of health and pedigree data of the boxer dogs. Relatively high heritabilities (0.10–0.30) for cryptorchidism, epilepsy, knee-problems and schisis were found in this study (Nielen et al., 2001b).

2.2. Application form

For a 6-month period (June 1 to December 1, 2000), breeders of the Dutch Boxer Club (DBC) sent in application forms for genetic-counselling, on each of which they indicated three desirable sires for one dam in a random order. The DBC had 251 registered breeders at that time. The breeder filled in the pedigree-id numbers of the dam, the three sires, and these animals' parents. Parent-id numbers were checked in the database of the birth cohort 1994–1995 of boxer dogs. The breeder's application was a prerequisite for mediation of puppy sale by the DBC. The breeders were asked to send in the application form prior to mating, with a minimum of 14 days before mating. In case the dam's heat occurred earlier than the breeder expected, the DBC would still mediate the puppy sale, as long as the form was received.

2.3. Counselling report

The counselling report gave odds ratios of all four traits for the three desirable dam–sire combinations, in the same random order as written on the application form by the breeder. Because we wanted to study the breeder's idea of 'the best dam–sire combination', no sire priority was given; so, the breeder could apply this health information like the other criteria used for sire selection. The breeders received the CR within 14 days after their completed application form was received by the research group.

2.3.1. Estimated breeding values

Parents pass on genes but not their genotypes to the next generation, genotypes being created afresh in each generation. This 'transmission value' of an individual (judged by the mean value of its progeny) is called the 'breeding value' of an individual (Falconer and Mackay, 1996). One cannot speak of an individual's breeding value without specifying the population in which it is mated. If an individual is mated to a number of individuals taken at random from the population, then its breeding value is twice the mean deviation of the progeny from the population mean. Breeding values usually are expressed in the form of

deviations from the population mean. Consideration of this definition will show that in a population, the mean breeding value must be zero (Falconer and Mackay, 1996).

Estimated breeding values were computed for the four health problems mentioned above for all known ancestors and for the progeny of boxer dogs related to dogs in our follow-up study 1994–1995. We were able to compute EBVs for the dam and sires indicated on the application forms when related to the dogs from this birth cohort. Pedigree information of 10,000 boxer dogs registered by the Dutch Kennel Club was linked to health data from the birth cohort 1994–1995. The presence or absence of the particular defect in a particular record (dependent variable) was modelled with a logistic-regression analysis (e.g., McCullagh and Nelder, 1989) with random sire and dam effects and random environmental effects (litter effect), common to a litter of pups (the models we used are described in Nielen et al., 2001b; for further reading on logistic models with random effects see Gianola and Foulley, 1983). Breeding values were computed from the random sire and dam effects. From pedigree records, a joint covariance-matrix for sire and dam effects was specified to take into account existing relationships between parents in the estimation procedure. The logistic model was run four times (once for each defect) to supply sets of EBVs (estimates of sire and dam effects for liabilities for each defect). The primary estimates of breeding values are expressed on the logistic scale, in log-odds units. By nature for a random effect, these EBVs will be centred around zero. Future records (in this case indicating liability for a particular defect in a litter of pups) then can be predicted as the average of the parental EBVs.

Absolute EBVs of different traits are difficult to compare because they depend on the heritability and prevalence for each trait. This means that high heritability and/or high prevalence relate to high EBVs. Heritability and prevalence of cryptorchidism was 0.24 and 10.7%, respectively; of epilepsy: 0.36 and 2.4%, respectively; of knee-problems 0.28 and 5.7%, respectively; and for schisis 0.27 and 2.3%, respectively (Nielen et al., 2001b). To mend this problem, odds ratios were computed for each trait and for each dam–sire combination on the basis of the available EBVs.

2.3.2. Odds ratios

Odds ratios were obtained by back-transforming the estimates on the logistic (log-odds) scale to the odds-scale, using the exponential function. The advantage of using ORs is that these estimates are independent of heritability or prevalence and have a more-direct link to the probability for acquiring a defect. With primary breeding values on the logistic scale centred around zero, ORs will be around 1, with values <1 indicating a below average risk and values >1 indicating an above average risk. Breeders were supplied with ORs for the three dam–sire combinations for each of the four traits. For this application of ORs, it is necessary to compute EBVs first by logistic-regression because effects are additive on this scale, and progeny liabilities can be predicted as parental averages only on this scale.

Because our counselling program was the first introduction to ORs for the Dutch boxer breeder, an important effort was made to inform the breeders about ORs through lectures, publications, and a special folder sent with every application form.

We presented the ORs to the breeders as ‘relative risks’ (RRs), a term which is more easily understood by statistical laymen. Although OR approximates RR for rare diseases, this is technically incorrect in our situation. However, in communication with the breeders, we considered the presentation of relative risks more comprehensible.

2.4. Evaluation form

To study how breeders choose a certain dam–sire combination, the breeders received a questionnaire together with their counselling report. They were requested to fill in and return this questionnaire using the enclosed stamped self-addressed envelope. The first question was whether one of the three sires on the application form was actually used for mating the dam. One out of three answers could be marked: yes, no, or the dam was not mated. If the answer was 'yes', the breeder was asked to write down the name and id-number of the chosen sire. To understand the breeder's choice for a certain dam–sire combination, we asked in what way different criteria influenced their sire choice. The criteria were: (i) exterior characteristics of the sire, (ii) performance of the sire in dog shows, (iii) known progeny of the sire, (iv) being the owner of the sire, and (v) the counselling report. We asked the owner to circle the number behind the criterion on a scale from 1 to 5: none (1), little (2), moderate ('as much as the other criteria') (3), strong (4), complete (5). There was also room to fill in other criteria. Additionally, each breeder was asked to indicate how the ORs for each of the four traits on the CR influenced their sire choice. This influence was measured on the same scale from 1 to 5 as described above.

The breeders were encouraged to comment freely on our counselling method, either in writing or by phone. To encourage breeders to do this, we left space on the evaluation form for comments and included a stamped self-addressed envelope to enhance returning it. Breeders who did not respond by the end of December were asked the same questions by phone.

3. Analysis

3.1. Evaluations

Genetic-counselling could not influence the breeder's choice when received after the dam had mated with one of the sires ($n = 29$), therefore those 29 breedings were excluded from the analysis. In order to study how a CR was used by the breeders we defined the CR to play 'a major role' in the breeder's choice for a certain dam–sire combination, when the breeder indicated the CR influenced his sire choice 'strongly' or 'complete'. The same definition was used for the major role of exterior characteristics of the sire, performance of the sire in dog shows, and known progeny of the sire. We fitted different logistic-regression models to relate 'whether or not the CR played a major role' to 'whether or not the other criteria played a major role', and whether the evaluation was in writing or by telephone. We used the Akaike's information criterion (AIC's) to determine the logistic-regression model that described our data best. The analyses included random breeder effects, to account for a possible breeder cluster effect.

3.2. Counselling report

We analysed the influence of the CR on sire choice of the 68 dam–sire combinations which were actually mated. In 14 cases, the breeder decided to use a sire not mentioned on

the application form. This decision was made mainly for practical reasons (meaning: they could not get to the sire of choice in time). None of the breeders indicated that the reason to choose another sire was related to the CR, therefore these 14 also were excluded from the analyses.

It was not possible to calculate ORs for all dam–sire combinations, because not all dam–sire combinations could be related to our birth cohort (see Section 2.3.1). Therefore, the number of dam–sire combinations on the CR for which ORs could be calculated varied from three to zero. A minimum of two combinations is required for each CR, so that we could compare ORs of different combinations ($n = 60$). Analysis of the influence of ORs on the breeders' sire choice was performed on data from these 60 CRs.

We determined whether or not the chosen combination had the lowest OR for cryptorchidism, epilepsy, knee-problems, or schisis. We calculated the range of the ORs (highest OR–lowest OR) for each trait of the 60 CRs with a minimum of two dam–sire combinations. We analysed whether or not the breeder's choice for the combination with the lowest OR was affected by this range. The difference in range of the ORs determines whether or not the breeder had a real choice. A small range means that the ORs for each dam–sire combination were alike, so this could not really influence the breeder's choice. However, a wide range means that the ORs for each combination differ considerably and in that case the breeder might choose the combination with the lowest ORs. Logistic-regression was used to determine 'whether or not the breeder chose the combination with the lowest OR' (dependent variable), could be explained by the range on the OR for a certain trait (continuous variable). Furthermore, we analysed whether or not this choice could be explained by the breeder indicating the CR to play a major role or not. This analysis was done with random breeder effects, to account for possible breeder cluster effects. We also compared the answers of breeders who used a sire indicated on the application form and those who did not. Furthermore, we compared the ORs of the non-chosen sires with the ORs of the chosen sires, to see if ORs of the non-chosen combinations were higher than the chosen combinations. For this analysis, we took the log of the median and used a two-sample *t*-test.

4. Results

4.1. Collected data

We received 129 application forms from 70 breeders, of which 39 (56%) submitted 1, 19 (27%) submitted 2, and 12 (17%) submitted 3 or more application forms. Of the application forms, 96 were filled in prior to mating. Logistic-regression did not show any breeder cluster effect. Of the evaluations of these 96 applications, 38 forms were completed and returned by the breeder; 58 evaluations were collected by phone. Logistic-regression did not show an effect of evaluation by writing or by telephone (Table 1).

The number of dam–sire combinations for which ORs were calculated could vary from 3 to 0 for each application (Table 2). Computing an OR for all dam–sire combinations was not possible, because the dam, the sire, and/or 1 or 2 parents from the Dutch sires originated from a foreign country.

Table 1
Akaike's information criterion (AIC's) of the logistic-regression models with random breeder effect of the indication of a major role of the counselling report (dependent variable) mentioned in 96 evaluation forms (The Netherlands, 2000)

Model	AIC
Intercept	120.1
Intercept + major role of exterior characteristics	113.3
Intercept + major role of (exterior characteristics + known progeny)	114.7
Intercept + major role of (exterior characteristics + champion + known progeny)	116.0
Intercept + major role of (exterior characteristics + champion + known progeny) + evaluations in writing or by phone	118.0

4.2. Evaluation form

4.2.1. Sire used for mating

Of the 96 application forms sent in prior to mating, 68 times the breeder used a combination mentioned on his application form. In 14 other instances, no mating was possible because the bitch had not been in heat at the time of evaluation. In another 14 instances, the breeder decided to use a sire not mentioned on the application form, mostly for practical reasons (e.g. bad weather, oestrus coming too early to arrange things properly).

4.2.2. Criteria used for choosing a dam–sire combination

'Exterior characteristics of the sires' was indicated as the most-important criterion for the sire choice, followed by 'known characteristics of the sire's progeny' and the CR (Table 3). Although it was the first time breeders received counselling, in 32% the CR was reported to play a major role in the choice of a dam–sire combination.

4.3. Counselling report

Fitting different logistic-regression models for the major role of the CR, with random breeder cluster effect, showed the lowest Akaike's information criterion for the model

Table 2
Frequency of the use of a boxer dam–sire combination mentioned on the application form in relation to the number of calculated odds ratio (ORs) on the counselling report (CR) (The Netherlands, 2000)

Number of dam–sire combinations for which ORs were presented on the CR	Number of CRs with the 'row number' of dam–sire combinations	Number of matings with one of the indicated sires on these CRs
3	54	37[a]
2	32	23[a]
1	6	3
0	8	5
Total	96	68

[a] Breeders actually could compare the ORs of these two or three different dam–sire combinations to choose the best dam–sire combination ($n = 60$).

Table 3
Score of the five criteria influencing the boxer-breeder's choice mentioned in 96 evaluation forms (The Netherlands, 2000)

Influence level	Criteria				
	Exterior characteristics	Champion	Known progeny	Owner of sire	Counselling report
None	3	11	12	68	27
Little	2	24	8	0	9
Moderate	33	43	26	20	29
Strong	42	13	39	5	23
Completely	16	5	11	3	8

with only the random breeder effect and a major role for exterior characteristics (Table 1). Including any other criterion, the AIC increased—meaning this was the best possible model to describe the data. Logistic-regression using this final model showed that assigning a major role to the CR was influenced by assigning a major role to exterior characteristics ($P = 0.001$) (Table 4). Of the breeders who attributed a major role to the exterior characteristics in choosing a dam–sire combination, 53% also indicated the CR to play a major role. Of the breeders who did not attribute a major role to exterior characteristics, only 19% indicated the CR to play a major role. Expressing a major role to the CR could not be explained by the major role of the performance of the sire in dog shows, by known characteristics of prior progeny or by the fact that evaluations were collected in writing or by telephone (Table 1). We did not further analyse the breeder being the owner of the sire, because this was only true for five breeders.

4.4. *Influence of ORs on choosing a dam–sire combination*

No differences could be shown between the provided ORs on the CR of breeders who did choose a sire indicated on the application form and those breeders who did not (two-sample *t*-test: cryptorchidism, $t = 0.48$, 90 d.f., $P = 0.63$; epilepsy, $t = 0.87$, 90 d.f., $P = 0.38$; knee-problems, $t = 0.67$, 90 d.f., $P = 0.50$); schisis, $t = -0.9$, 90 d.f., $P = 0.35$).

In case of CRs with two or three combinations, we expected a relationship between the width of the range and the breeder choosing the combination with the lowest OR. However, for none of the traits was the choice of the dam–sire combination with the lowest OR related to the range of the OR of that trait (Table 5). This means that larger differences between ORs

Table 4
Estimates (*b*) of the final logistic-regression model of the influence of 'the major role of the counselling report (CR)' (dependent variable) mentioned in 96 evaluation forms, with random breeder effect (The Netherlands, 2000)

Final model	Levels	*b*	S.E.	*P*	OR
Intercept		−2.98	0.17		
Major role of exterior characteristics	Yes	2.65	0.78	0.001	12.6
	No	0.00			

Table 5
Estimates (*b*) of the logistic-regression model of the relation between the boxer breeder's choice for the dam–sire combination with the lowest odds ratio (OR) (dependent variable) and (1) the range of the ORs (continuous variable) of each trait (range) on the counselling report (CR) and (2) the indication of 'a major role of the CR' (major role CR) from 60 evaluation forms in response to a CR with two or more ORs (The Netherlands, 2000)

Model per trait	Levels	*b*	S.E.	*P*-value
Cryptorchidism				
Intercept	–	−1.37		
Range of ORs	n.a.	0.88	1.48	0.55
Major role CR	Yes	0.67	0.58	0.24
	No	0.00		
Epilepsy				
Intercept		−1.24		
Range of ORs	n.a.	0.72	0.90	0.43
Major role CR	Yes	1.23	0.56	0.03
	No	0.00		
Knee-problems				
Intercept		−0.95		
Range of ORs	n.a.	−1.4	1.63	0.39
Major role CR	Yes	1.18	0.58	0.04
	No	0.00		
Schisis				
Intercept		−0.57		
Range of ORs	n.a.	−0.19	1.36	0.89
Major role CR	Yes	−0.21	0.57	0.71
	No	0.00		

of the possible combinations did not influence the breeder's choice. However, there was a relation between the choice of a dam–sire combination with the lowest OR for epilepsy and assigning a major role to the CR ($P = 0.03$). The odds ratio was 3.4, indicating that the dam–sire combination with the lowest OR for epilepsy was chosen about three times more often by breeders indicating that the CR did play a major role in sire choice, than by breeders indicating the CR did not. A similar relation was found between the choice of a dam–sire combination with the lowest OR for knee-problems and the indication of a major role of the CR ($P = 0.04$, odds ratio $= 3.3$).

4.5. Free comments by breeders

Only a few breeders commented freely on the written evaluations. By phone they expressed their thoughts more extensively, but the contents were comparable. Breeders said that the sire should match the dam (meaning they aim to compensate less-desirable characteristics of the dam by the opposite features of the sire, or vice versa). According to the breeders, a good dam–sire match was mainly based on 'experience' and 'the eye of the master.'

Breeders stated that they had many years of experience and knew the health status of both their breeding animals and its progeny very well. Some questioned high ORs, saying

that if it really was a problem, they would have heard about it. Breeders considered (congenital) diseases evident in the first 7 weeks relatively less important, compared to diseases developing after the puppy is sold. With respect to knee-problems, the genetic basis was questioned in spite of research results in boxer dogs (Nielen et al., 2001b); instead environmental influences were overestimated. Many respondents were disappointed that there was no counselling for heart problems or for hip dysplasia. Breeders (95% dam owners) were likely to blame the sire when high ORs for a certain dam–sire combination were calculated. Although most breeders argued for open communication about health problems, they were reluctant to have ORs published with the dog's id-number.

5. Discussion

Although it was the first time that Dutch boxer breeders could make use of genetic-counselling, 32% of them indicated that the CR played a major role in their sire choice. Traditionally, breeders select their breeding animals on exterior characteristics and performance in dog shows. This is consistent with our result that 'exterior characteristics' and 'known progeny' appeared to be the most-important criteria for sire choice. This is supported by the breeders' opinion that a good dam–sire match mainly is based on 'experience' and 'the eye of the master'. It might imply, however, that breeders are not sufficiently aware that parents pass on genes—but not their genotype—to the next generation (Falconer and Mackay, 1996). Of the breeders attributing a major role to a sire's exterior characteristics as a selection criterion, 53% also ascribed a major role to the CR. This indicates that about half the breeders using traditional criteria, might make progress with respect to the health status of their animals. This view is sustained by our finding that there was a relation between the choice of the dam–sire combination with the lowest OR for epilepsy and ascribing a major role to the CR. In the present study, however, a OR < 1 for all four health traits was calculated for only six dam–sire combinations. Hence, focussing on one genetic disease at a time would enhance the use of the CR for the Dutch breeders.

Only 54% of the counselling reports included ORs for all three dam–sire combinations, because of the use of foreign dogs. The percentage foreign dogs of known ancestors in the first generation of dogs in the boxer cohort was 8.7% (Nielen et al., 2001a). The fraction of foreign dogs used in a population, shows how breeders try to increase the genetic diversity in that population. This can lead to the 'popular sire' effect (if many offspring of imported animals are born) and the average inbreeding coefficient after the first generation increases due to breeders only using a few, sometimes-related foreign dogs (Nicholas, 2003).

Although breeders did not appear to rank the four health problems, there was a tendency to put epilepsy and knee-problems above the other traits. In their comments, however, breeders indicated that they considered diseases emerging in the first 7 weeks (one of which could be cheilopalatoschisis) relatively less important compared to diseases developing after the puppy is sold. The dam–sire combination with the lowest OR for epilepsy was chosen about three-times more often by breeders attributing a major role to the CR than by breeders who did not. This might indicate that breeders who want to decrease the frequency

of a certain genetic disease, take care that their decisions at this point coincide with their overall breeding strategy.

Breeders generally have to select for or against several characteristics. It was difficult for them to pick and choose from the additional, new—and in some respect, threatening—health information of their dogs. This was especially so in our study, because ORs of four different traits had to be compared (Leighton, 1999). Also, in most cases, selection of the best dam–sire combination with respect to a certain health problem was not the combination of choice with respect to another health problem. The finding that only six dam–sire combinations showed ORs below the population average for all four traits, emphasised the breeders' interpretation problems.

In this study, breeders could define their own priority. They did not receive a set of weights or coefficients of importance for the sire choice criteria. Weighting factors help to express the relative importance of a characteristic to the breeder. In cattle and pigs, the weighting factors reflect the relative contribution of a characteristic to economics (Hermesch et al., 2003). In dog populations, weighting factors could express the relative contribution of a certain characteristic to the health status of animals in a population. The task of dog breeders to select simultaneously for several characteristics could be facilitated by adding weighting factors to genetic-counselling programs. It is our opinion that parent clubs should formulate the goal of the breeding program before such counselling starts. However, goals like this will be reached only if breeders can find the right balance between health and beauty, and parent clubs acknowledge the importance of continuous registration of genetic disease. Good counselling comes from good health registration (Patterson et al., 1987). This, however, implies a continuous effort in collecting recent health data in a population. The more genetic-counselling is based on outdated information, the more ORs based on this information will approximate the average OR in the population—and will be less valuable for adequate selection.

In the free comments, breeders frequently emphasised the importance of genetic-counselling for future dog breeding in The Netherlands. This opinion was partly reflected in the answers to the question how genetic-counselling had influenced their choices, because 32% of the breeders indicated that the genetic-counselling played a major role in their sire choice (Table 3).

Results of our continuing genetic-epidemiological research will reveal new information on late-onset diseases (e.g. cancer, hip dysplasia), which can be used in future counselling programs. Because Dutch breeders of boxer dogs have indicated to be interested in these diseases, their acceptance of genetic-counselling may increase simultaneously.

6. Conclusion

At this early stage of genetic-counselling, breeders hesitated to put population interest above personal interest and above short-term individual interest. Nevertheless, they acknowledged the value of counselling, especially to reduce the frequency of serious disorders such as epilepsy and knee-problems. Breeders expressed greater concern for later-onset diseases than for diseases emerging before puppies are sold.

Acknowledgements

This study would not have been possible without the cooperation of the breeders. We greatly appreciate their effort.

References

Brass, W., 1989. Hip dysplasia in dogs. J. Small. Anim. Pract. 30, 166–170.

Falconer, D.S., Mackay, T.F.C., 1996. Introduction to Quantitative Genetics. Longman Group Ltd., Harlow, pp. 184–204.

Famula, T.R., Oberbauer, A.M., 1998. Reducing the incidence of epileptic seizures in the Belgian Tervuren through selection. Prev. Vet. Med. 33 (1–4), 251–259.

Gianola, D., Foulley, J.L., 1983. Sire evaluation for ordered categorical data with a threshold model. Annales de genetique et de secetion evolution. Genet. Sel. Evol. F 15, 204–224.

Hall, S.J., Wallace, M.E., 1996. Canine epilepsy: a genetic counselling programme for Keeshonds. Vet. Rec. 138 (15), 358–360.

Hedhammer, A., 1991. Breeding healthier dogs in Sweden. Tijdschr. Diergeneeskd. 116 (Suppl. 1), 76S–79S.

Hermesch, S., Kanis, E., Eissen, J.J., 2003. Economic weights for feed intake in the growing pig derived from a growth model and an economic model. J. Anim. Sci. 81, 895–903.

Leighton, E.A., 1999. Using estimated breeding values to reduce the incidence of genetic diseases in dogs. In: Proceedings of the Meeting of the International Elbow Working Group, pp. 1–14.

Leppanen, M., Saloniemi, H., 1999. Controlling canine hip dysplasia in Finland. Prev. Vet. Med. 42 (2), 121–131.

Leppanen, M., Paloheimo, A., Saloniemi, H., 2000. Attitudes of Finnish dog-owners about programs to control canine genetic diseases. Prev. Vet. Med. 43 (3), 145–158.

Lingaas, F., Klemetsdal, G., 1990. Breeding values and genetic trend for hip dysplasia in the Norwegian golden retriever population. J. Anim. Breed. Genet. 107, 437–443.

McCullagh, P., Nelder, J.A., 1989. Generalized Linear Models, 2nd ed. Chapman & Hall, New York.

Nicholas, F.W., 2003. Introduction to Veterinary Genetics. Blackwell Publishing Ltd., Oxford, pp. 122, 187, 188.

Nielen, A.L.J., van der Beek, S., Ubbink, G.J., Knol, B.W., 2001a. Population parameters to compare dog breeds: differences between five Dutch purebred populations. Vet. Quart. 23, 43–49.

Nielen, A.L.J., Janss, L.L., Knol, B.W., 2001b. Heritability estimation for diseases, coat, colour, body weight and height in a birth cohort of boxers. Am. J. Vet. Res. 62, 1198–1206.

Ostrander, E.A., Rine, J., Sack Jr., G.H., Cork, L.C., 1993. What is the role of molecular genetics in modern veterinary practice? Special commentary. J. Am. Vet. Med. Assoc. 203, 1259–1262.

Patterson, D.F., Aguirre, G.A., Fyfe, J.C., Giger, U., Green, P.L., Haskins, M.E., Jezyk, P.F., Meijers-Wallen, V.N., Schiffer, S.P., 1987. Canine genetic disease information system. Am. Kennel Gazette 104 (7), 58–61.

Patterson, D.F., 1993. Understanding and controlling inherited diseases in dogs and cats. Tijdschrift voor Diergeneeskunde 118 (Suppl. 1).

Smith, C.A., 1994. Current concepts. New hope for overcoming canine inherited disease. J. Am. Vet. Med. Assoc. 1 (204), 41–46.

Swenson, L., Audell, L., Hedhammar, A., 1997. Prevalence and inheritance of and selection for hip dysplasia in seven breeds of dogs in Sweden and benefit: cost analysis of a screening and control program. J. Am. Vet. Med. Assoc. 210 (2), 207–214.

van Oost, B.A., 1998. The role of molecular genetics in the diagnosis of diseases in companion animals: an introduction. Vet. WQ. Suppl. 1, S88–S89.

Willis, M.B., 1989. Control of inherited defects in dogs. J. Small Anim. Pract. 30, 188–192.