Increasing Longevity with Estimated Breeding Values

10th Bernese Mountain Dog International Health Symposium

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- Introduction of EBVs
- EBV for longevity: Bernese Mountain Dog data
- Some conclusions

Longevity as a trait in breeding

- Combination of traits
- Underlying traits influenced by many genes
- Underlying traits influenced by environmental factors
- No lifespan information of reproducing dogs themselves

Longevity as a trait in breeding

Complicated!

BUT

With a large amount of data, hopefully some regularities can be found

If they are genetic, breeding for longer lifespan is possible

Estimated Breeding Value

- **BLUP** (Best Linear Unbiased Prediction)
- Statistical estimation method, which takes simultaneously into account
  - All the information available from relatives
  - Environmental factors
- In the 1980s: production animal breeding
- In 1996: Finnish Hound, hunting traits (Liinamo et al.)
  - 2002 Hip and elbow dysplasia

Frequency of canine hip and elbow dysplasia decreasing in Finland

10.9.2014 | Koiran terveys, Terveystarkastukset

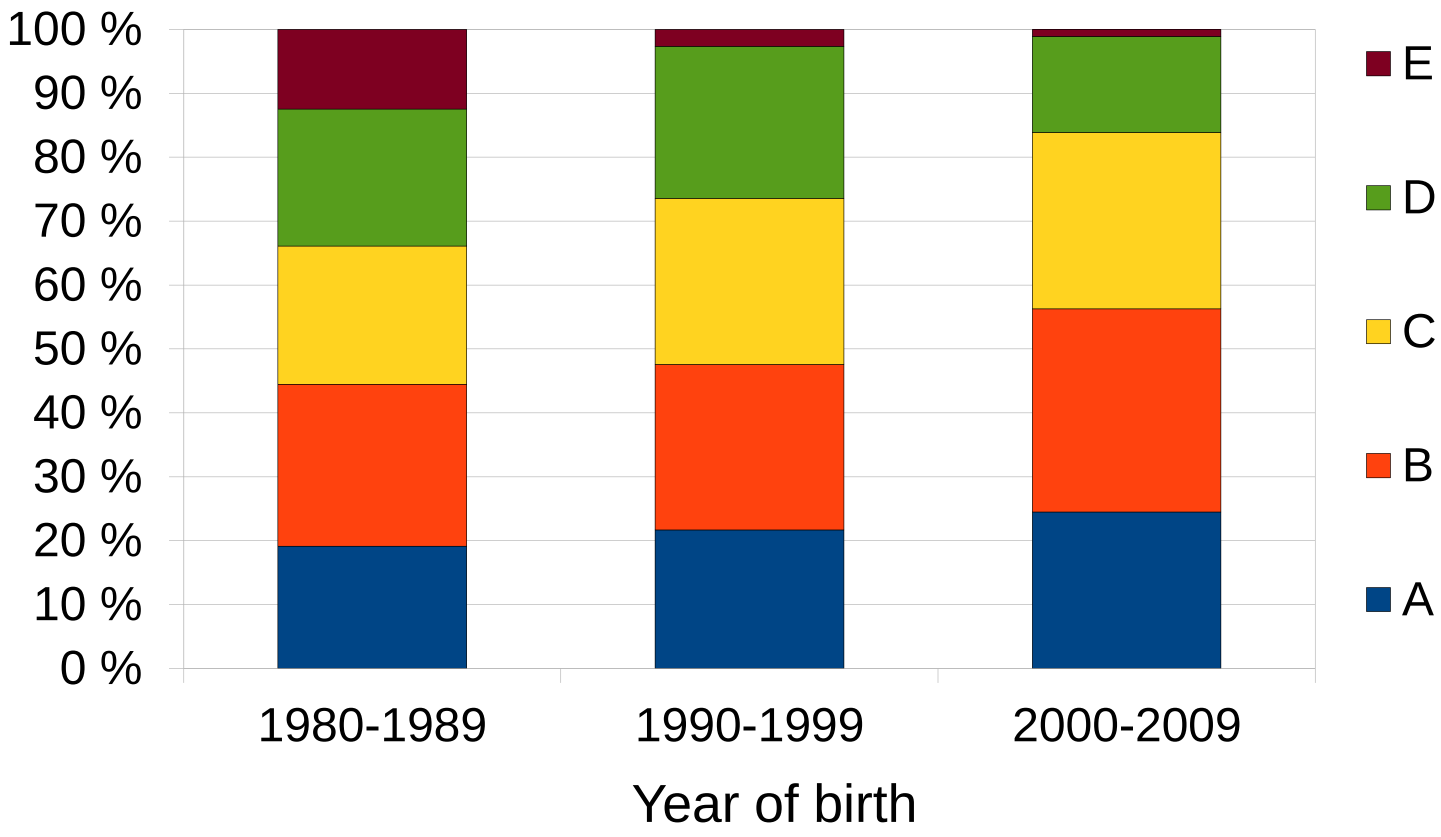
Genetic trends for hip and elbow dysplasia were assessed for the dogs born during the years 1993-2012. In hip dysplasia, the largest improvement can be seen in the Saint Bernard, the Smooth Collie, the Newfoundlander, the Beauceron and the Bordercollie. In elbow dysplasia, the Rottweiler and the St.Bernard have improved the most.

Genetic trends for hip and elbow dysplasia were assessed from the mean EBVs of the dogs born during the years 1993-2012. EBVs are being estimated for about 55 breeds in the Finnish Kennel Club, and these breeds were included in the assessment. Improvement in the mean EBVs was proportioned to the phenotypic screening results (Tables 1 and 3). A change of one point means that the breed average has moved one letter (hip dysplasia) or number (elbow dysplasia) to either a better or a worse direction.

Most of the assessed breeds are improving in hip dysplasia

Genetic improvement in hip dysplasia had taken place in almost every breed studied (Table 2). The largest improvement could be seen in the Saint Bernard, the Smooth Collie, the Newfoundlander, the Beauceron and the Bordercollie. An average hip joint of the Saint Bernard in the 1990s was in the middle of C and D. In the 2010s it is only slightly worse than B.

Hip dysplasia in Finnish BMDs



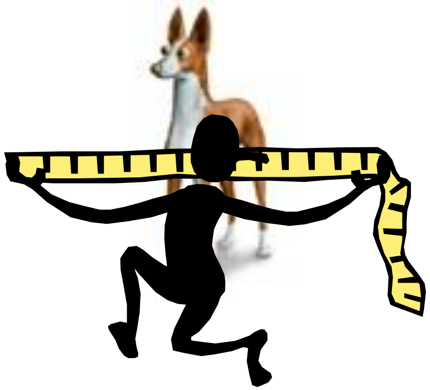
EBVs – for which traits?

- Traits with **many genes** (quantitative / polygenic / multifactorial)
- Traits where **environmental** effects play a role
  - Own phenotype does not tell much about genotype
- In practice:
  - Routine, systematic collection of data
  - Genetic differences (variation) exist among dogs

Bernese Mountain Dog data

- Finnish breed club has gathered data on lifespan and cause of death of BMDs since 1995
  - Finnish dogs, also some Swiss and German
  - August 2015: 2924 dogs
  - In addition: Still Going Strong -dogs
- First EBV estimation in 2012
- Updating 1-2 times a year

Bernese Mountain Dog data



- Two data sets -> two different indices
    - Dataset 1: only dead dogs
    - Dataset 2: also Still Going Strong (SGS) dogs
- Mean lifespan
    - 8.1 years
    - SGS dogs (205 individuals): 9.1 years

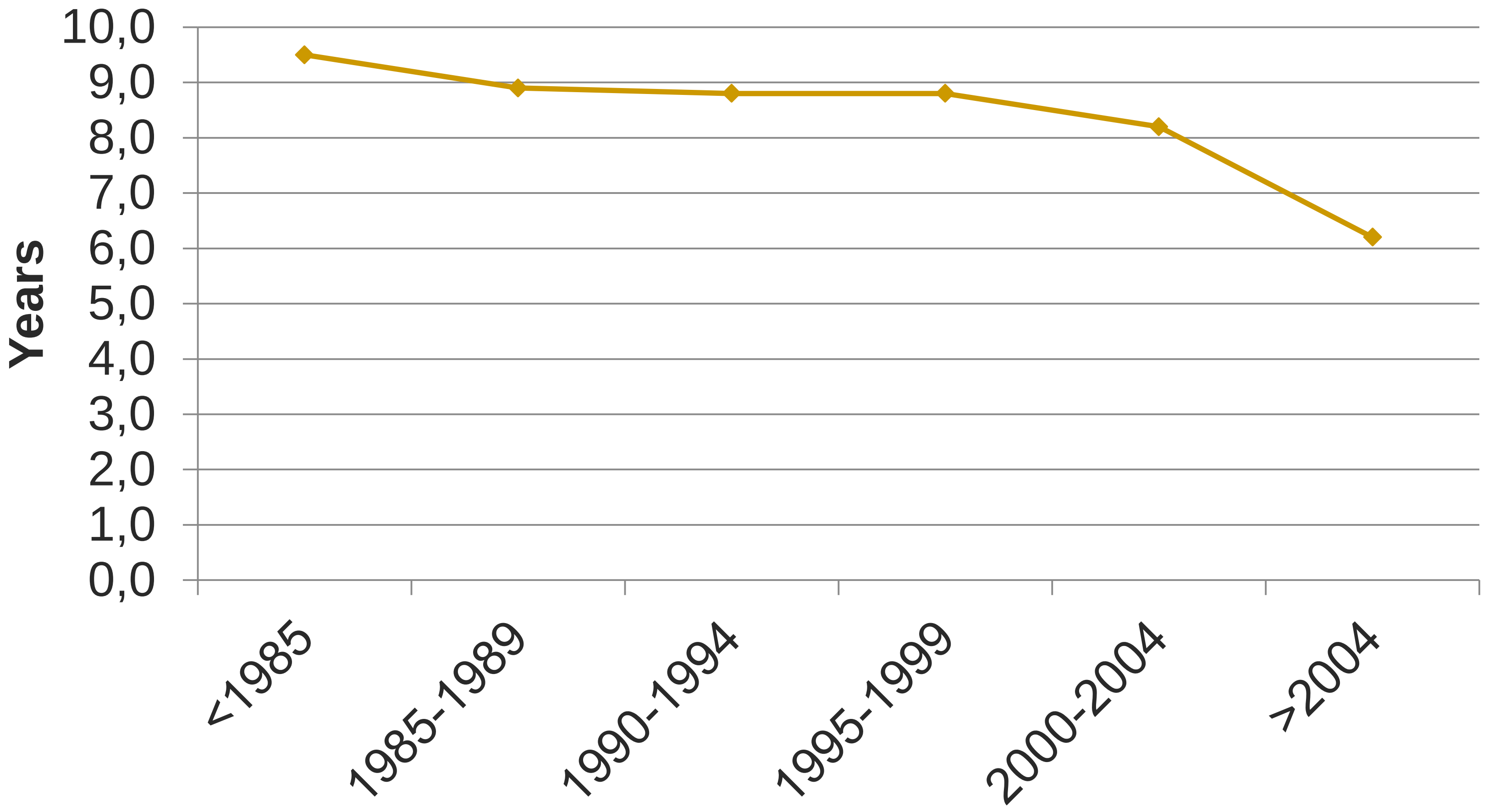
Environmental factors

- Factors included in the estimation model:
  - Sex, country, year of birth, cause of death, litter
- Effects of these factors are taken into account in the EBVs
  - EBVs of males and females as well as dogs in different countries are comparable
- This correction can be done only for factors on which recorded data exist
  - BUT data from relatives helps to level off the influence of environmental factors

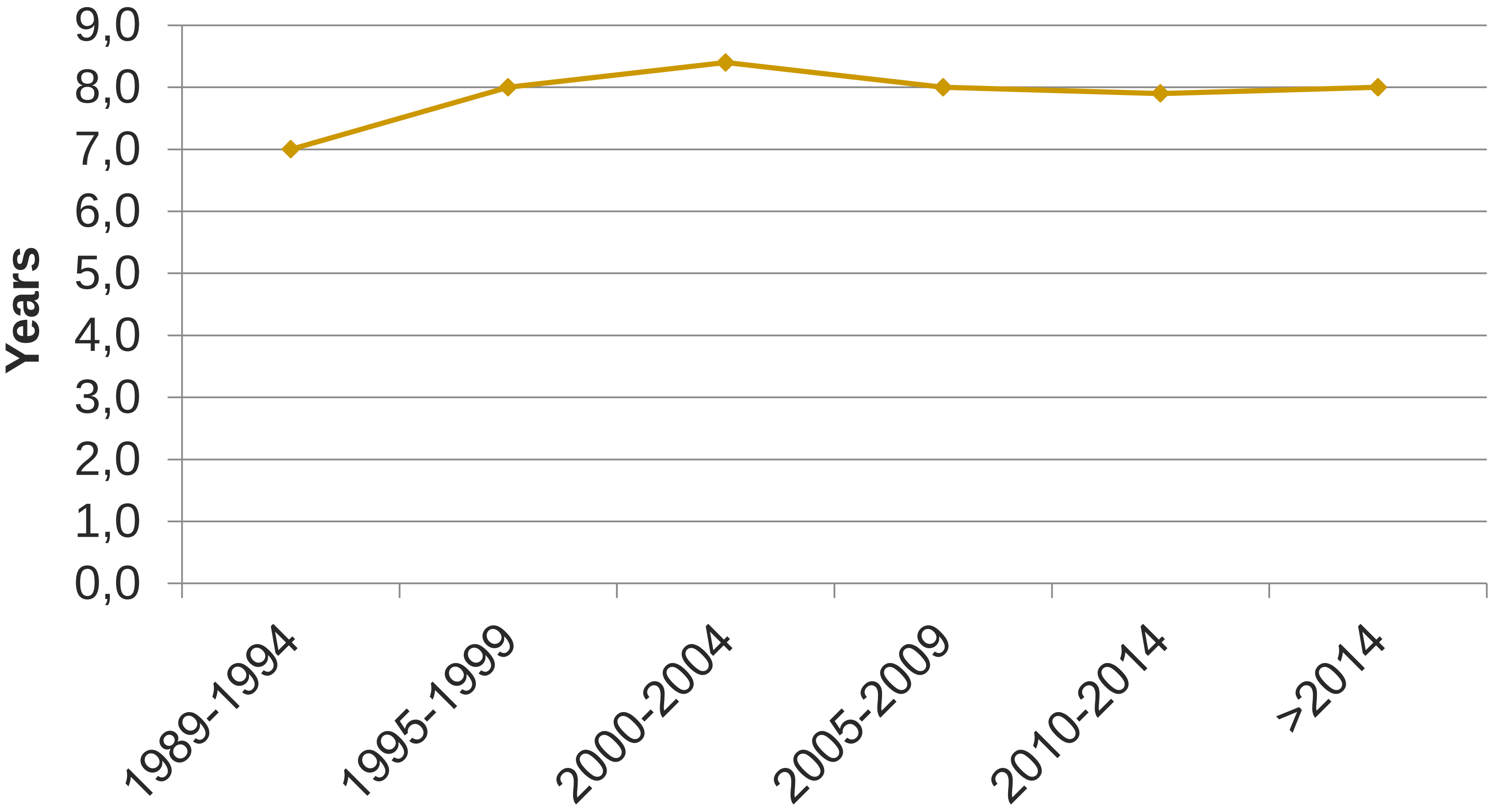
Effect of sex and country

- Sex: mean lifespan
  - Females 8.4 years
  - Males 7.7 years
- Country: mean lifespan
  - Two largest groups (2763 and 297 dogs): 8.0 years
  - Smallest group (65 dogs): 8.7 years

Effect of birth year



Mean lifespan by year of death



Cause of death

Cause of death	N	Mean lifespan
Old age	118	11.5
Musculoskeletal	209	6.6
Tumors or immunological	728	7.4
Other diseases (mainly internal organ)	168	6.8
Temperament	21	4.7
Accidents (incl. poisonings)	79	3.7
No reason given / other reason / other disease / open diagnosis	336	6.7

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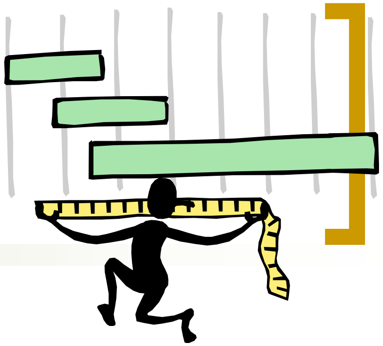
Info lacking for 1470 dogs

Genetic differences among dogs



- Heritability
    - Describes genetic variation as a proportion of total variation in a given trait
    - If no genetic differences exist, heritability is 0 and selection yields no improvement
- Estimate of heritability *in this given population:*
    - Dataset 1: 7% (11% in previous update)
    - Dataset 2 (SGS incl.): 9% (16 % in previous update)
- Estimate of heritability can change in every update as more data accrues

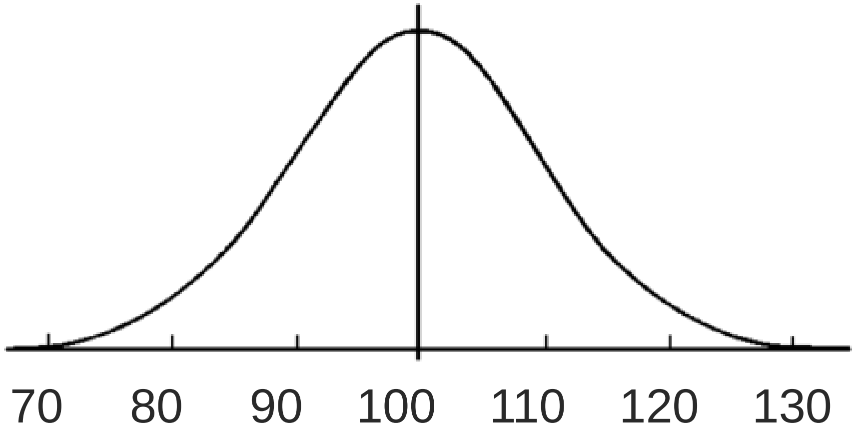
”The calculation formula” i.e. linear mixed model

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + \alpha A^{-1} \end{bmatrix} \begin{bmatrix} b \\ a \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix}$$

- **a = a vector containing animals’ breeding values**
- b = a vector containing environmental factors
- y = a vector containing phenotypic values of the traits
- X, Z = coefficient matrices linking phenotypic values with related environmental factors and breeding values
- A^{-1} = a matrix containing genetic relationships between the animals
- α = proportion of genetic differences (heritability)

Standardization of EBVs

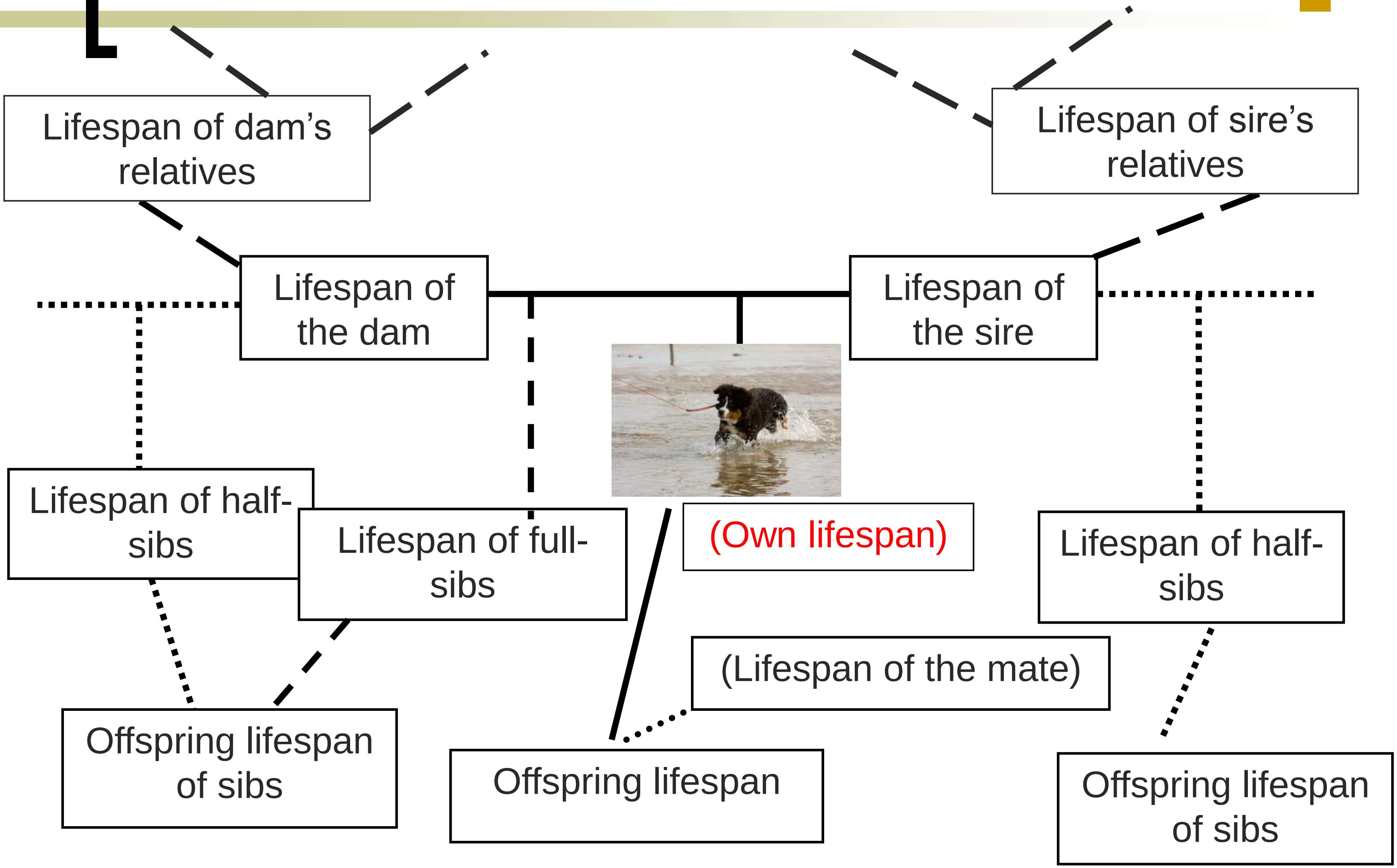
- Mean EBV in the population = 100
- The larger the EBV the better the breeding value of the dog
- 75% of the dogs get an EBV between 90 and 110
- Varies usually between 70-130



Accuracy of EBVs

- EBV for longevity: phenotypes of breeding candidates are not known
  - Accuracy depends on heritability
  - Accuracy depends on the amount and reliability of longevity data from relatives

Information from relatives



Lifespan of dam's relatives

Lifespan of sire's relatives

Lifespan of the dam

Lifespan of the sire

Lifespan of half-sibs

Lifespan of full-sibs

(Own lifespan)

Lifespan of half-sibs

(Lifespan of the mate)

Offspring lifespan of sibs

Offspring lifespan

Offspring lifespan of sibs

Examples of accuracies with different information sources

Results	**$h^2 = 10\%$**	$h^2 = 25\%$	$h^2 = 50\%$
Sire or dam	**0,16**	0,25	0,35
sire+dam	**0,23**	0,35	0,50
1 own+1 offspr.	**0,35**	0,53	0,73
1 own+s+d	**0,38**	0,57	0,76
1 own+5 offspr.	**0,44**	0,63	0,79
1 own+40 offspr.	**0,73**	0,87	0,93
0,00 - 1,00 = 0-100%	**Longevity**, hunting traits	ED in BMD	HD

Longevity EBV - conclusions

- Difficult trait to analyze
- Many factors affecting the lifespan of a dog
  - Many of them cannot be taken into account when estimating EBVs
- Low accuracies
  - But more accurate than using only phenotypes of relatives
  - Combines together all the available info
  - In the future perhaps genomic breeding values could be added in the model

Thank you! ☺

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