INBREEDING EFFECTS ON LITTER SIZE AND LONGEVITY IN DOGS

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Inbreeding: why it is a concern in dogs health

A mating practice more or less common in dogs:

- 24% of French dog breeders indicate having planned mating between close-related dogs (Leroy et al. 2007)
- In a study of 10 breeds, the proportion of dogs inbred considering 2 generations, ranging from 2 to 8% according to the breed (Leroy and Baumung 2010)

Yet some consequence on breed health

- Increased occurrence of abnormalities due to a single recessive allele
- Impact of inbreeding depression on reproductive traits or occurrence of specific diseases (Mäki et al. 2001, Urfer 2009)

Close-breeding practices forbidden by some breed and kennel clubs

I. Introduction and context
Aim of the study

Analysis of the consequences of inbreeding on prenatal and postnatal survival in purebred dogs, with two traits considered:

- Litter size: detailed results
- Longevity: preliminary results

Investigation on eventual effects of inbreeding purge, by comparing ancestral and new inbreeding
### Material & methods

Data used from the French Kennel Club database:
- Longevity: declarations for dog death between 2007 and 2012 (10% of dogs on average)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Breed code</th>
<th>Litters produced (90-12)</th>
<th>No of declaration of death (07-12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No of Litters</td>
<td>No of Sires</td>
</tr>
<tr>
<td>Basset Hound</td>
<td>BSH</td>
<td>3,468</td>
<td>608</td>
</tr>
<tr>
<td>Cairn terrier</td>
<td>CAI</td>
<td>8,846</td>
<td>1,178</td>
</tr>
<tr>
<td>Epagneul breton</td>
<td>EPB</td>
<td>23,005</td>
<td>5,402</td>
</tr>
<tr>
<td>German Shepherd</td>
<td>GSD</td>
<td>39,080</td>
<td>6,966</td>
</tr>
<tr>
<td>Leonberger</td>
<td>LEO</td>
<td>3,246</td>
<td>848</td>
</tr>
<tr>
<td>West Highland White Terrier</td>
<td>WHW</td>
<td>16,163</td>
<td>1,629</td>
</tr>
</tbody>
</table>

Pictures: SCC/ I. Horvath
Material & methods

Model used when considering litter size

- Litter size $Y_{ijksdp}$ considered as a trait of the dam

\[ Y_{ijks} = \mu + PR_i + By_j + b_1F_L + b_2F_s + b_3F_d + A_d + Cs_s + Cd_d + Br_k + \epsilon_{ijksdp} \]

- $PR_i$: litter rank effect (fixed)
- $By_j$: birth year (fixed)
- $b_1, b_2, b_3$: regression coefficients for inbreeding effects
- $F_L, F_s, F_d$: inbreeding coefficients of litter, sire and dam, respectively
- $A_d$: dam genetic effect (animal model)
- $Cs_s$: common sire effect, related to semen quality for instance (random).
- $Cd_d$: common dam effect, related to prenatal environment (random)
- $Br_k$: breeder effect (random)
- $\epsilon_{ijks}$: residual error

A model will also be investigated considering ancestral $F_a$ and new $F_n$ inbreeding (Kalinowki et al. 2000)
II. Results – Litter size

General results

<table>
<thead>
<tr>
<th>Breed</th>
<th>Breed code</th>
<th>Avg litter size</th>
<th>Avg litter rank</th>
<th>Equiv No of generations known</th>
<th>F (%)</th>
<th>F_n (%)</th>
<th>F_a (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basset Hound</td>
<td>BSH</td>
<td>5.14</td>
<td>2.21</td>
<td>6.34</td>
<td>3.92</td>
<td>3.43</td>
<td>0.49</td>
</tr>
<tr>
<td>Cairn terrier</td>
<td>CAI</td>
<td>3.89</td>
<td>3.04</td>
<td>6.46</td>
<td>3.25</td>
<td>2.83</td>
<td>0.42</td>
</tr>
<tr>
<td>Epagneul breton</td>
<td>EPB</td>
<td>5.32</td>
<td>2.53</td>
<td>8.77</td>
<td>5.02</td>
<td>3.44</td>
<td>1.58</td>
</tr>
<tr>
<td>German Shepherd</td>
<td>GSD</td>
<td>5.1</td>
<td>2.87</td>
<td>5.39</td>
<td>2.42</td>
<td>2.06</td>
<td>0.36</td>
</tr>
<tr>
<td>Leonberger</td>
<td>LEO</td>
<td>6.33</td>
<td>1.92</td>
<td>6.68</td>
<td>3.21</td>
<td>2.33</td>
<td>0.87</td>
</tr>
<tr>
<td>West Highland White Terrier</td>
<td>WHW</td>
<td>3.47</td>
<td>2.87</td>
<td>5.81</td>
<td>2.35</td>
<td>2.1</td>
<td>0.25</td>
</tr>
</tbody>
</table>

- Average litter size ranged from 3.5 to 6.3 according to the breed
- Average inbreeding ranged from 2.4 to 8.8% according to the breed
- Ancestral inbreeding generally low (under 1%) except for Epagneul breton
II. Results – Litter size

Heritabilities

<table>
<thead>
<tr>
<th></th>
<th>BSH</th>
<th>CAI</th>
<th>EPB</th>
<th>GSD</th>
<th>LEO</th>
<th>WHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h^2$ (s.e.)</td>
<td>0.058 (0.013)</td>
<td>0.097 (0.018)</td>
<td>0.097 (0.01)</td>
<td>0.085 (0.008)</td>
<td>0.0831 (0.027)</td>
<td>0.104 (0.013)</td>
</tr>
</tbody>
</table>

Heritabilities range between 6 and 10%
II. Results – Litter size

**Inbreeding effects**

<table>
<thead>
<tr>
<th>F regression coefficients</th>
<th>BSH</th>
<th>CAI</th>
<th>EPB</th>
<th>GSD</th>
<th>LEO</th>
<th>WHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Litter</td>
<td>-1.43$^{NS}$</td>
<td>-2.2$^{***}$</td>
<td>-2.95$^{***}$</td>
<td>-3.42$^{***}$</td>
<td>-3.58$^{NS}$</td>
<td>-1.28$^{***}$</td>
</tr>
<tr>
<td>F Sire</td>
<td>0.04$^{NS}$</td>
<td>0.16$^{NS}$</td>
<td>0.89$^{NS}$</td>
<td>1.15$^{NS}$</td>
<td>0.71$^{NS}$</td>
<td>1.06$^{NS}$</td>
</tr>
<tr>
<td>F Dam</td>
<td>-0.74$^{NS}$</td>
<td>-1.17$^{NS}$</td>
<td>-0.85$^{NS}$</td>
<td>-2.14$^{***}$</td>
<td>-3.65$^{NS}$</td>
<td>-1.38$^{*}$</td>
</tr>
</tbody>
</table>

$^{NS}$ non significant, $^{*}$ P <0.05, $^{***}$ P<0.001 after Bonferroni correction

- Four out of six breeds show significant impact of litter inbreeding on litter size
- No significant impact of sire inbreeding
- Two out of six breeds show significant impact of dam inbreeding on litter size
Ancestral and new inbreeding effect
The case of Epagneul breton

<table>
<thead>
<tr>
<th>F Regression coefficients</th>
<th>F new</th>
<th>F ancestral</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Litter</td>
<td>-3.78***</td>
<td>-0.94 NS</td>
</tr>
<tr>
<td>F Sire</td>
<td>0.26 NS</td>
<td>1.95 NS</td>
</tr>
<tr>
<td>F Dam</td>
<td>-2.63***</td>
<td>3.59*</td>
</tr>
</tbody>
</table>

NS non significant, * P <0.05, *** P <0.001

- New inbreeding: significant negative impact for Litter and Dam inbreeding
- Ancestral inbreeding: positive moderately significant impact for Dam inbreeding → Inbreeding purge effect?
II. Results – Longevity

Relation between inbreeding and longevity

preliminary results

- A bimodal distribution of longevity
- Longevity decreased with the average body weight of the breed
II. Results – Longevity

Relation between inbreeding and longevity

Average longevity for the 6 breeds according the inbreeding level

- Significant lower longevity when inbreeding increased for two breeds: In German Shepherd and Epagneul Breton, dogs with $F > 12.5\%$ live on average one year less than dogs with $F < 6.25\%$.

- When considering first results for survival analysis, some convergence problems remains.
Low values of heritability were estimated for litter size. This should be increased with better recording.

Still some work to do on longevity, even if some other preliminary analysis suggest lifespan heritability around 0.14-0.15 (Mäki 2011).

Our results outline the impact of inbreeding on prenatal and postnatal survival.

Mating between relatives leading to large inbreeding values should be avoided.

For the moment, no clear evidence of inbreeding purge