Report on the Results of the 2017 Havanese Longevity Survey

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Executive Summary:

During the last quarter of 2017 a sample of 512 dogs was accumulated for the Longevity Survey. About 88% are Havanese Club of America (HCA) member owned. The results of the Longevity Survey indicate that male and female Havanese live on average to approximately 13.0+/-0.3 years of age. There is no significant difference in the average lifetime of males and females. The lifetime distribution exhibits two distinct peaks; the first (with about 20% of the population) is narrow and centered near 9.6 years, while the second is broader and centered near 14.5 years. While somewhat more evident in males than females, it shows that dogs and bitches making it past their 9th - 10th birthday exhibit lifetimes much longer than the average. A dog alive at age 12 for example will have an average lifetime of almost 15 years and overall, almost a third of all dogs will survive to between 15 and 19 years.

The distribution of 7 year and older living dogs independently corroborates this observation. There we see a dip in the number of living 8 to 9 year olds, compared to the expected number, and again it is somewhat more prominent in the males. Year to year changes in AKC registrations do not appear to account for this dip.

While the agreement of the two observations is compelling, the overall statistical significance is still too weak to claim a definitive effect. However, taken together, the evidence from the shape of the lifetime distribution and the distribution of older living dogs, paints a picture of a generally long lived breed with some yet unknown factor or factors contributing to the earlier death of a small percentage of the population.

Motivation:

The Health Committee of the HCA recommended to the HCA Board in the summer of 2017, that a short survey be conducted to estimate the lifespan of Havanese. This is a breed that is said to be "long lived" but to our knowledge, no quantitative data exists to demonstrate it. The Health Committee also wanted data that could be used to estimate the costs of targeted health studies in the future. The HCA Board approved a short survey be conducted in the last quarter of calendar year 2017 to estimate the average lifespan of Havanese, and the distribution of the age of the current population of older living Havanese.

Methodology

The survey was conducted in a manner that was largely anonymous – responders had the option to remain completely anonymous if they chose to do so.

Data collection started at the 2017 Havanese Nationals (Sept. 2017) and data additions ended Dec 31, 2017. The initial survey was passed out in paper form at the registration desk at the Nationals. At the end of the Nationals we had information on about 40 dogs. After the Nationals, we asked for input via email to the HCA member's list and also made the survey available on the HCA website. Eventually we expanded the input to the survey to all the regional clubs asking input from their memberships. Finally we solicited input from the online Havanese Health and Show forums. At the end of the survey we had data on 512 living and dead Havanese.

During the process, we asked that responders be careful not to duplicate information if the dog(s) were co-owned.

The Survey was very simple and asked only that the dogs that were reported were AKC registered. This allowed us to use AKC registration numbers by year, to check for any systematic biases. Jane Ruthford has been our intermediary with the AKC getting that registration data.

Next, we asked if the owner was an HCA member, or a member of a regional or other AKC club. Data from non – HCA members was initially kept separate but later combined as it was not inconsistent with the member data.

The survey asked two specific questions:

1) the age at natural death of any Havanese for which you were the primary owner or co-owner. Please indicate the sex (M or F) and exclude those that died from unnatural causes (accidents, etc.). If uncertain, briefly describe the cause of death.
2) the age and sex of all living Havanese, 7 years or older that you currently own or co-own.

In order to encourage participation, we did not ask for detailed information on health issues, cause of death, etc. although a number of responders proffered the information. As stated earlier, responders had the option to remain anonymous.

<u>Statistics of the Response</u>

We received 143 survey responses. Of those, 28 responders (19.6% of the total) were not HCA or Regional club members, or other AKC breed club members. A total of 513 dogs were reported. One female dog under the age of 5 months was removed, as death resulted from a clear congenital defect. That left 512 dogs in the survey. The average number of dogs reported per survey responder is 3.6 (=512/143) although some of the responders had significantly larger numbers of dogs to report -- notably breeders or individuals who were some of the very early Havanese owners.

Table 1 shows the breakdown of the responses. About 88% of all the dogs are owned and reported by HCA members. The ratio of male to female in the two samples (Question 1 and Question 2) are very close: each approximately 40% male and 60% female. This ratio is notably different than yearly AKC registrations (see the last section) by sex. The registered male to female fraction between 2008 and 2016 is about 46%:54% from AKC statics. The lower male fraction in the HCA sample may be due to the greater breeder representation in the HCA sample (breeders often keep fewer males than females).

Table 1: Survey Statistics

Questions	Number of Males	Number of Female	Total	Non – HCA Fraction
Q1: Age at Natural Death	59 (38%)	97 (62%)	156	12.2%
Q2: Living and 7 yrs or older	148 (42%)	208 (58%)	356	12.1%
Total dogs or bitches	**207 (40%)**	**305 (60%)**	**512**	**12.1%**

Mortality Findings

Figure 1 shows the distributions of the age at natural death for males, females and the total. The horizontal axis is the age in bins of 1 year –for example, the first bin are the age 0 but less than 1 year of age dogs. The youngest dog was a female that died between 2 but less than 3 years of age. The oldest dog was a male that died between its 18th and 19^{th} birthday.

Table II shows the mean or average lifetime and the statistical error on the average. The error is mathematically estimated from the width (RMS) of the distribution (see next paragraph) and the number in the population. As many responders stated just the age in years, we placed the age in the center of the age bin, and introduced an additional systematic error of +/-0.3 on the average age of death.

The average lifetime of males (12.9+/-0.5 years) and females (13.0+/-0.3 years) is consistent within the measurement errors as being identical: 13.0 +/-0.3 (+/-0.3 systematic) years.

Also shown in Table II is the root-mean-square (RMS) of the mortality distributions. The RMS gives you the width (or spread) of the distribution. Roughly, if you take the average age +/- twice the RMS, you will have captured about 95% of the population. For example, for females, the average is 13.0 years and the RMS is 3.3 years. Accordingly, about 95% of the female population should lie between 7.4 (=13.0-2x3.3) years and 19.6 (=13.0+2x3.3) years. We see from Figure 1 that 6 females out of 97 total lie outside that window, or ~94% lie within the window, as expected.

Sometimes people prefer to quote the median lifetime rather than the average. The median lifetime is the point in the distribution where half the population lies below and half the population lies above that age. If the distribution is almost symmetric about the average, the median and the average will correspond closely. For males and females the medians are approximately 13.9 (+/-0.3) years and 13.5 (+/- 0.3) years, respectively. The combined median is about 13.6 (+/-0.3) years. These are a little larger than the averages, as the sampled distributions are skewed slightly towards earlier deaths, pulling down the average. The skewness will be discussed below.

Figure 2 shows the survival probability for males, females and both. The survival probability is defined here as *the probability of still being alive at the age value of the lower edge of each bin on the horizontal axis*. For example, the first two points correspond to 1 and 2 years of age and we see that they are all 100% because the first death (1 female) occurs later, between 2 years but less than 3 years of age. The death is reflected in the next point corresponding to 3 years of age, which has female survival probability of 99% (=1 female out of 97 died earlier), male survival probability of 100% (=no males out of 59 died earlier), and combined probability 99.4%(=1 male + female out of 156 died earlier).

Because statistics are so low, one has to take the results cautiously. The overall scale error in males + females is ~ 8 percent. But, in age bin by age bin, the error is much greater as you go out to older ages, because our sample is so small.

Figure 3a puts that data in a more interesting format. It shows the average expected age of death if the dog has already survived to a certain age. We have included the error bars on the male + female points to show how the uncertainty increases as you go out in years, because the number of remaining dogs used to estimate the lifetime diminishes much faster than the RMS of the remaining population.

To read this plot, note that curves start off at ~13 years for the first few years since no dogs have died yet. As a simple example, if you've survived to 9 years of age, then your average lifetime is predicted to be approximately 14+/-0.3 years. This is not unexpected, because as you go up in age, young dogs are removed from the population and the average lifetime from the remaining population *rises*.

Figure 1: Age at Natural Death

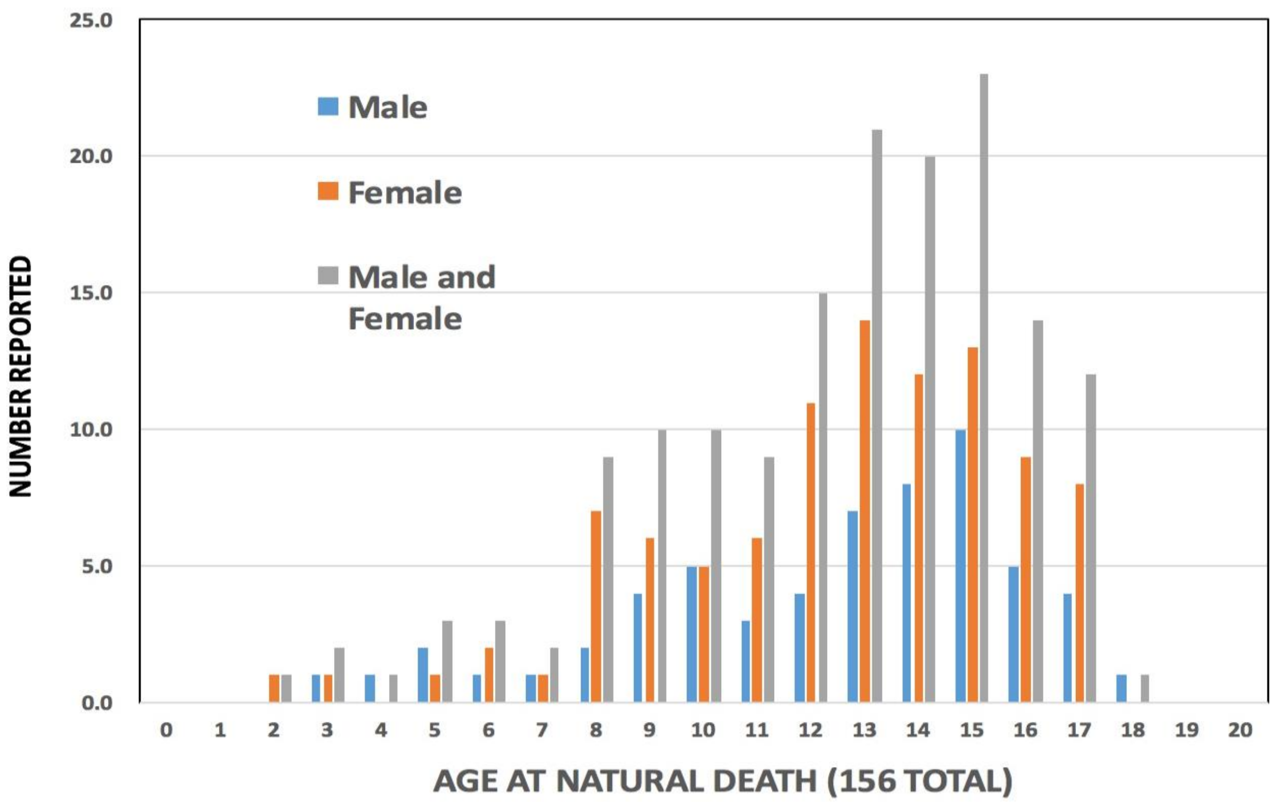


Table II: Average Lifetime and RMS Width

Sex	Number Reported	Average Lifetime (years)	Error on Average (years)	RMS Width of Distribution (years)
Male	59	12.9	0.5	3.6
Female	97	13.0	0.3	3.3
Male+Female	156	13.0	0.3	3.4

Figure 2: Survival Probability

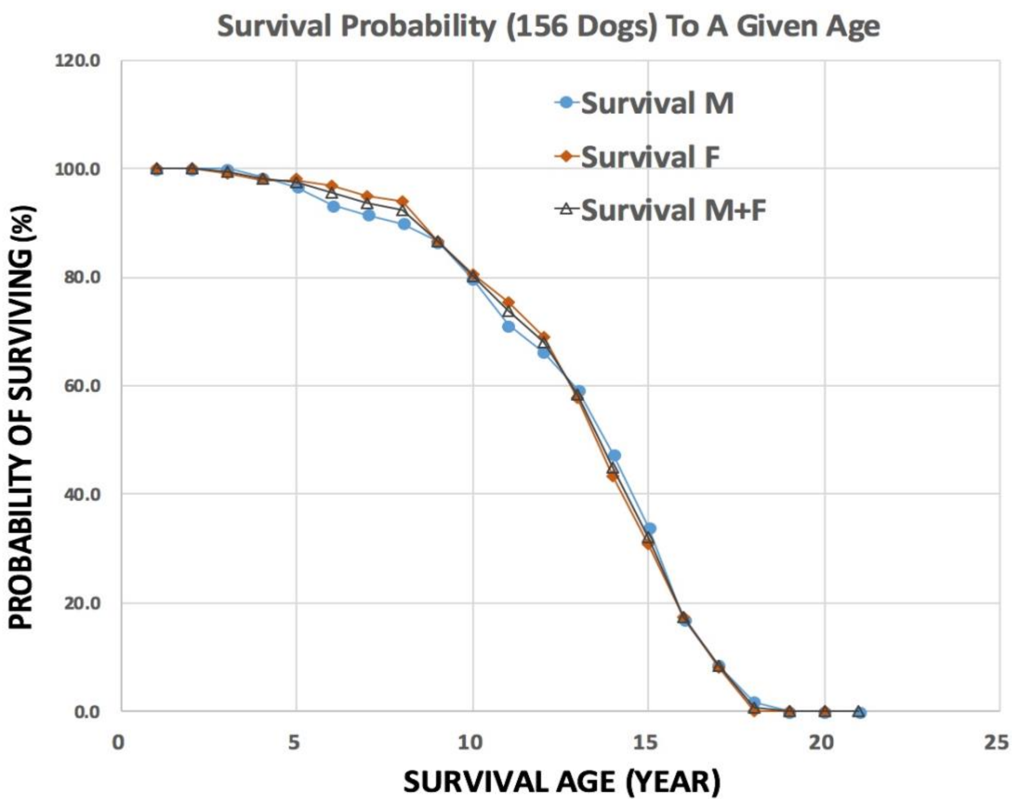
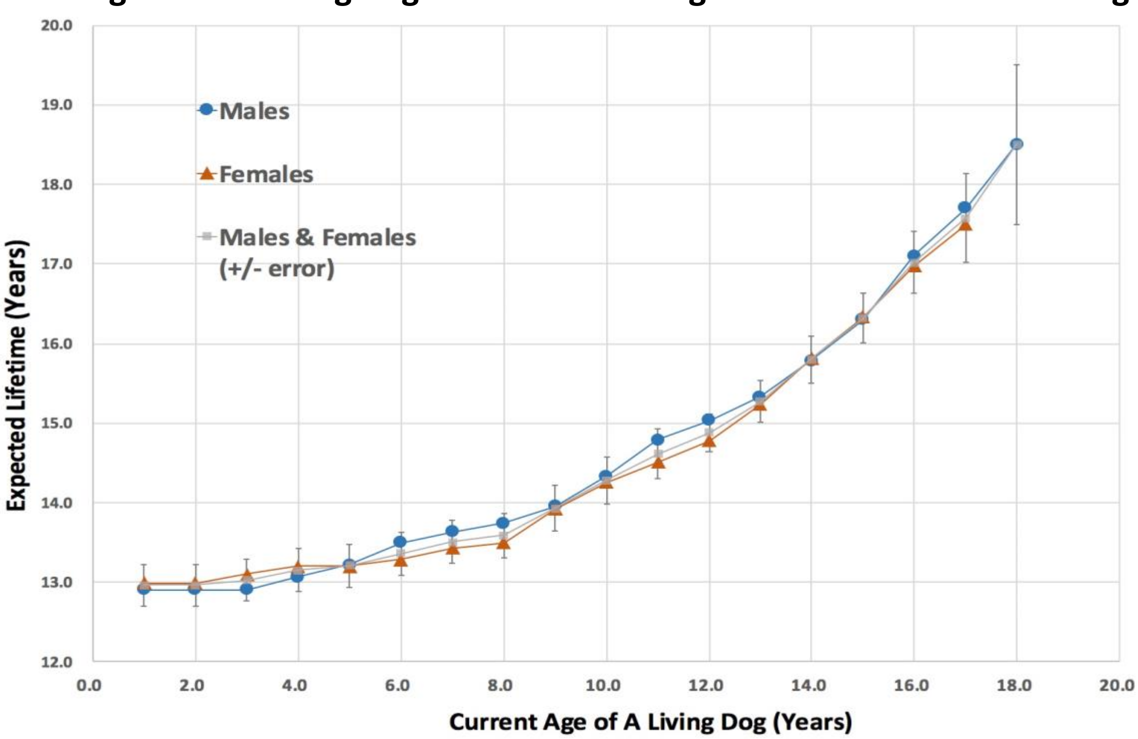


Figure 3a: Average Age at Death if a Dog Has Survived to a Given Age



The subtle feature of the measured curves in Fig 3a is that their slopes appear to change (the rate of the *rises*) – the slopes appear to increase in several steps with age. As we will show next, this feature is expected if the underlying distribution is "bi-modal" meaning it exhibits two distinct peaks.

Figure 3b shows an example of a *hypothetical* model of a bi-modal distribution which is not unlike the real measured one seen in Figure 1 for males. It is manually constructed to make the features clearer, with two Gaussian peaks near where we see possible peaks in our data (around 9-10 and 14-15 years) and with a similar relative area. If one calculates the average lifetime, it is 13 years, like our data. Figure 3c shows the same model distribution scaled to 59 entries (the number of males in the survey), along with the real data from the 59 males in Figure 1. By construction, there is fairly good agreement in shape, but there are somewhat more early deaths (below ~7 years) in the real data, than in this simple hypothetical model.

Figure 3b: Hypothetical Example of a Bi-Modal Distribution

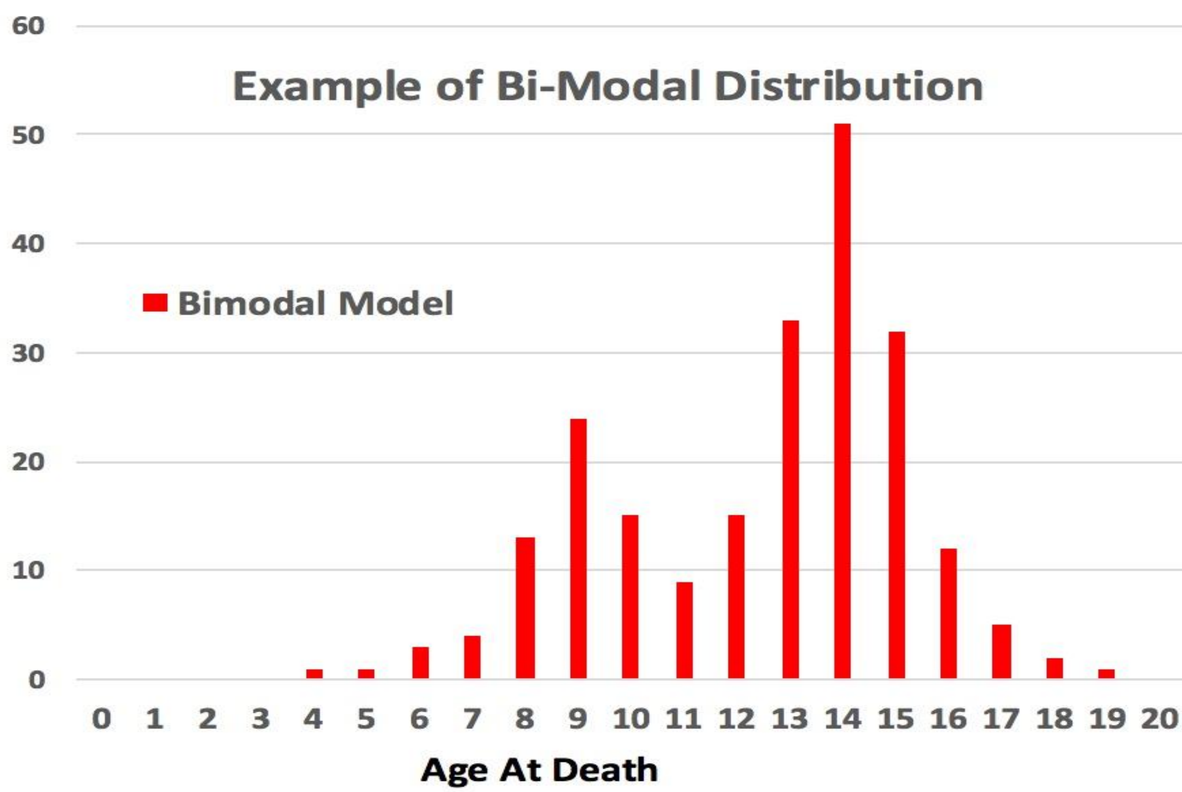
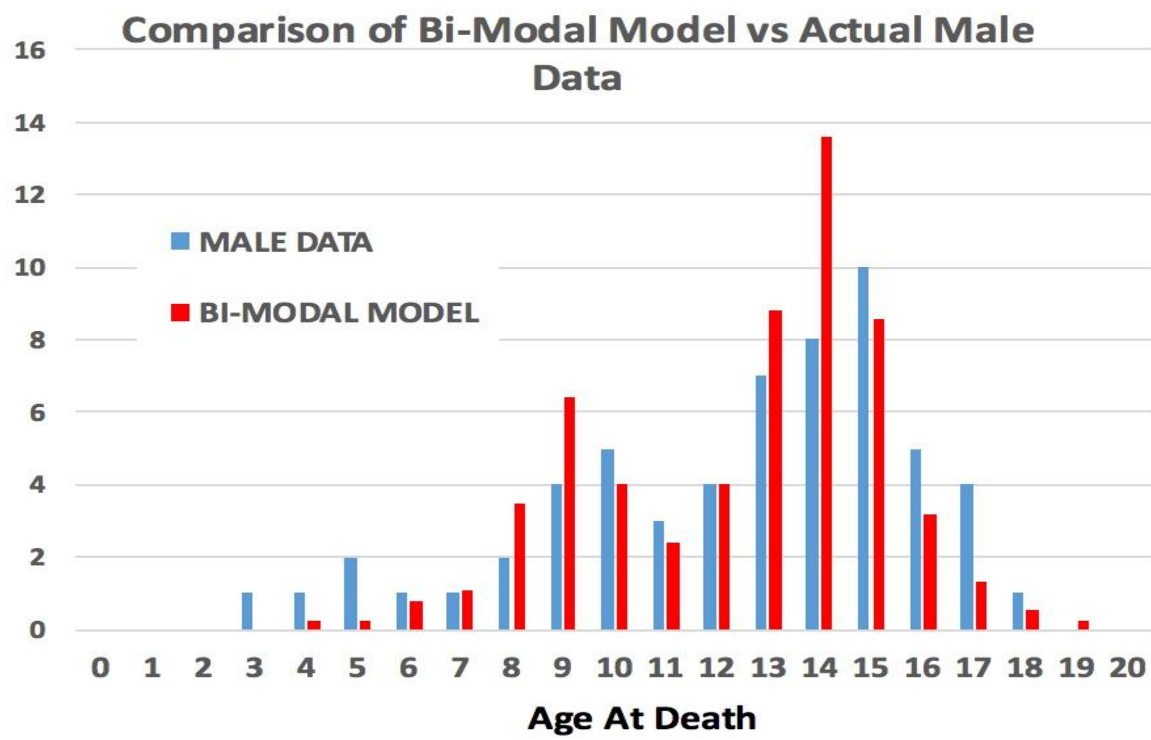
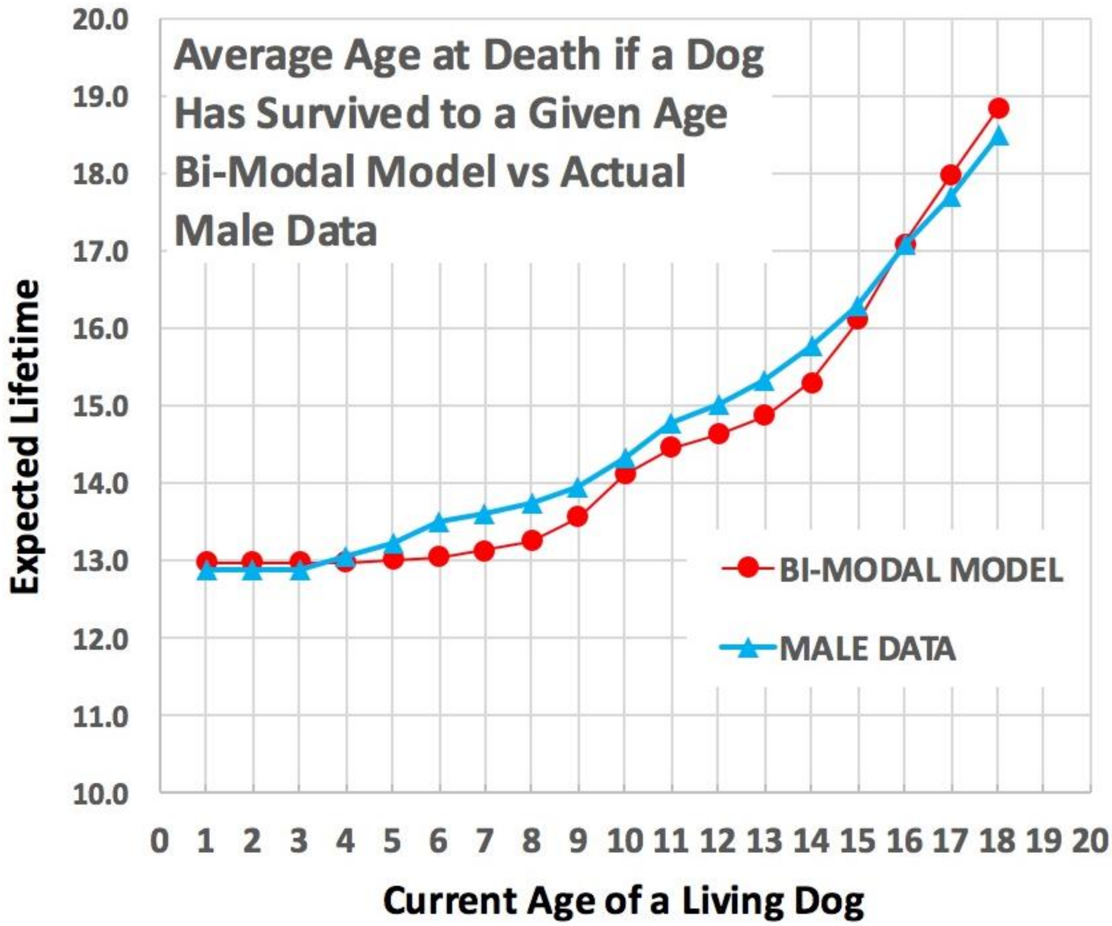


Figure 3c: Bi-Modal Model Compared to Data from 59 Males



In Figure 3d we take this model and calculate the average age at death if you survive to a given age (as was done in Figure 3a with the real data). We see again that the model starts flat at ~13 years and rises slowly with two changes in slope. For a direct comparison we added in blue, the curve from the actual male data (Fig. 3a). Unfortunately, our statistics are small, making these subtle features harder to discern, but the features and shape are not-dissimilar to the curve for males. The differences are largely caused by not including in the hypothetical model the early deaths, and more exact positions and widths of the two peaks.

Figure 3d: Average Age at Death Calculated from Hypothetical Bi-Modal Model and Compared with Male Data



Finally, we try to formalize this and understand the actual uncertainties. We take the mortality data from Fig. 1 of our survey and perform a fit (a simple chi-square minimization) to that data using the correct statistical errors from the measured data.

The fitting function is composed of two Gaussian probability distributions (each have 3 parameters: the area under the curve which gives the number of dogs, the position of the peak, and the width of the peak). In addition, we add a flat distribution from 0 to 7.5 years of age to accommodate the few early deaths we observe in the data. Finally, we impose a constraint that the total area of the combined distribution equals the actual number of surveyed dogs. In total there are 7 parameters to the fit, and we have 21 bins of data (or 21-8 degrees of freedom).

The results are shown in Table III for each of these fits, along with the errors on the fitted parameters. Plots of the data and the fitted distributions are shown in Figures 4a, 4b and 4c. All the fits all have high probability (the fit chi square/degree of freedom is low).

Table III: Results of Fits to the Mortality Distributions for Males, Females and the Sum of Males and Female

Parameter	**Male**	**Female**	**Male+Female**
# in Lower Peak	13.4+/-6.6	12.3+/-4.2	29.1+/-6.7
Mean of Lower Peak (y)	10.1+/-0.7	8.9+/-0.2	9.6+/-0.3
Lower Peak Width (y)	1.1+/-0.6	0.6+/-0.3	1.1+/-0.2
# in Upper Peak	39.6+/-6.8	77.4+/-4.9	114.3+/-6.9
Mean of Upper Peak (y)	14.9+/-0.6	14.1+/-0.3	14.5+/-0.2
Upper Peak Width (y)	1.7+/-0.4	2.1+/-0.3	1.9+/-0.2
Flat Background if <7.5y	0.7+/-0.5	0.9+/-0.5	1.6+/-0.5
# In Fit Area (Constraint)	59	97	156

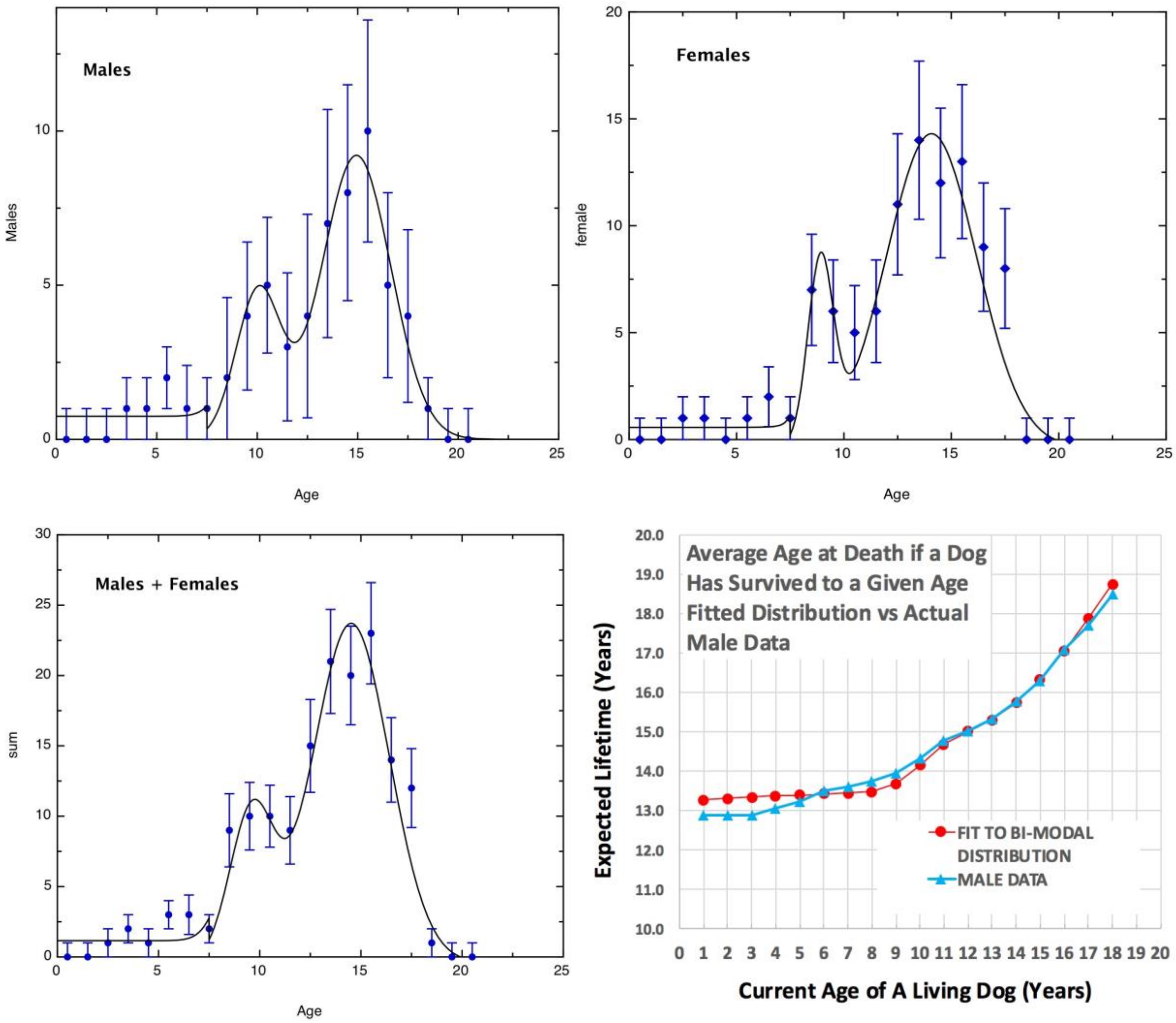
We see from the fits that the lower and upper peaks in males and females are both consistent with about 9.6+/-0.3 and 14.5+/-0.2 years, respectively. The width of the upper and lower peaks are also consistent between males and females; the lower peak is narrower (~1 year) and the upper peak wider (~ 2 years). Statistically, the peaks are both distinct in position and width.

About 20% of the population lies in the lower peak. Within errors that fraction is the same for males and females, albeit the fit is somewhat higher for males than females, because the fitted lower peak is narrower for females than males.

Finally, the flat background suggests that about 8+/-3% of the population dies somewhat earlier than 7.5 years.

In Fig 4d we repeat Fig 3d, but now with the fitted longevity distribution for males from Table III. The agreement with the data is now seen to be excellent.

Figure 4: Data & fitted curves for (a) 59 males, (b) 97 females, and (c) 156 males and females. Figure 4d: Average age at death as predicted by fit, after survival to a given age.



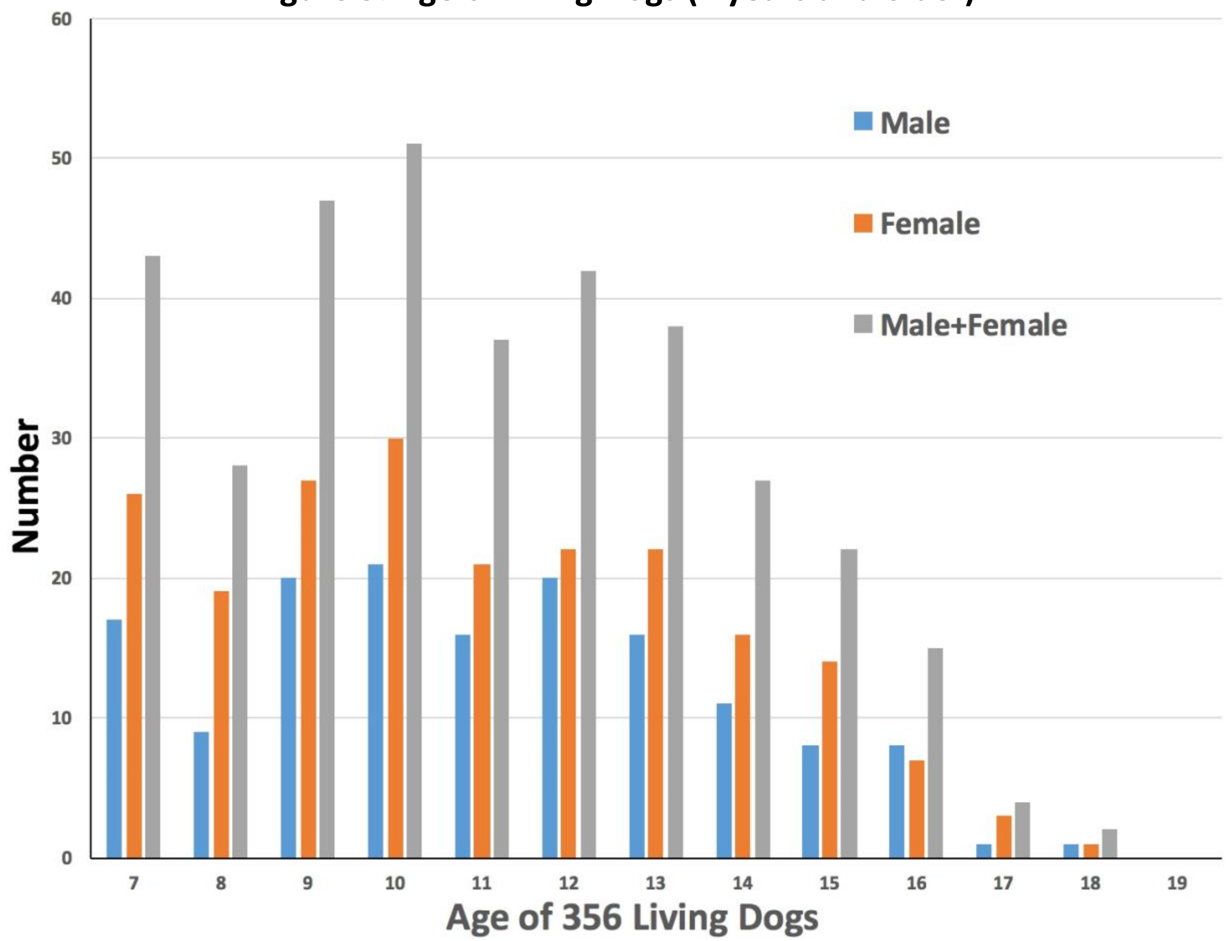
Findings On Living Dogs, 7 Years and Older

The distribution of the age of 356 living dogs – 7 years and older - is shown in Figure 5. For example, the first bin of youngest dogs corresponds to dogs at least 7 years old, but less than 8 years and contains 17 males and 26 females, for a total of 43. The oldest reported dogs are a male and female between 18 and 19 years old.

One of the interesting features of the distribution is the apparent dip in the number of 8 to 9 year olds in what we would otherwise expect to be a smooth distribution.

From a statistical standpoint, if we assume the parent distribution is continuous and smooth, the chance of seeing 9 males (in the 8 to 9 year olds bin) when you expect 18.5 (the average of the adjacent lower and upper bins) is about 1 chance in 155. The chance of seeing 19 females when you expect 26.5 is 1 chance in 36. The dip appears in both males and females, but is more significant in males than females.

Figure 5: Age of Living Dogs (7 years and older)



When you combine them, the chance of seeing 28 males plus females when you expect 45 is 1 chance in 546. We have used Poisson statistics to calculate these probabilities. Statistically this is a ~3.6 standard deviation effect. This is interesting, but not yet significant enough to claim that something is going on. Scientific studies typically demand 5 standard deviations or more to claim an unexpected effect in a single measurement. More statistics are needed. If the effect existed at the current rate of occurrence, we would need at least twice more data (or a total of ~ 700 living dogs) to demonstrate that it is real and not just a statistical fluctuation.

Recall however that the longevity distribution (Figure 1) provides completely *independent* information. There we saw evidence that the distribution is bi-modal, --- one peak around 9 to 10 years and one later around 14 to 15 years. The effect was more prominent in the males, just like we see in Figure 5.

Taken in combination, the two pieces of independent information suggest that one or more processes result in earlier deaths in ~ 20% of the population. But one must be cautious drawing conclusions, because the statistics are very low.

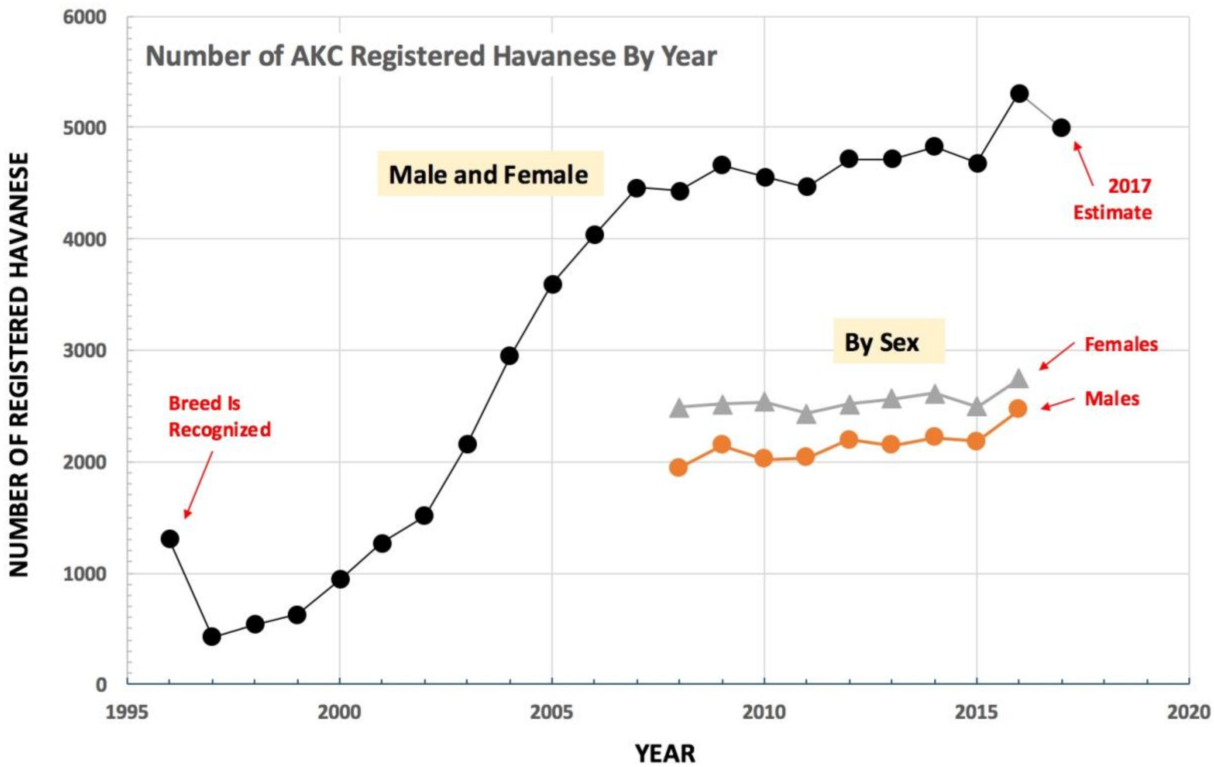
Comparison With AKC Registrations

According to the AKC, there were close to 64,000 Havanese registered between 1999 and 2016. They believe that only about half the dogs in these litters actually get registered. To complete the curve through 2017 we have taken the 2017 registrations as the average of the previous two years, as an estimate. Adding in the 2017 estimate, we come to close to 69,000 registered dogs. Figure 6 shows the registrations per year, and also individual male and female numbers that were available from 2006 to 2016. As indicated earlier, the average number of registered males is somewhat higher (~ 46% male, 54% female) than we see in our survey (~40% male).

Using the AKC registration data from 1999 forward, we can combine it with our survival probability data from Figure 2 to estimate the current population of living registered Havanese (at the end of 2017). To do this, we have weighted the data in the survival rates we have measured to reflect the actual male to female ratio in the AKC registrations. Where unavailable, we have also taken the male to female ratio as the average from 2006 to 2016. Both of these are small corrections.

Figure 7 shows the resultant predicted age distribution of living AKC registered Havanese at the end of the year 2017. We expect there to be over 58,000 living registered Havanese at that time. In detail, we predict for example, 6 registered dogs at least 18 but less than 19 years of age, and 79 that are at least 17 years old, but less than 18 years of age. Notable is the lack of a dip near 8-9 yrs of age, suggesting that annual registration numbers do not account for the dip seen in our survey's data.

Figure 6: AKC Registration Data



Finally, in Figure 8 below, we replotted Figure 5 data, adding (in blue) the AKC population curve from Figure 6 and scaling the entries to our total sample size (356) of 7 year or older dogs. In Figure 8, the grey and blue bars should be compared, as they are both the male and female combined population. Note that because the male to female ratio is slightly different (40% males in our sample and 46% males in the AKC sample) we might expect some small differences.

We see from the comparison that the living AKC population as a whole appears younger than the dogs in our survey which are largely HCA member owned and weighted towards breeder or show-home owners. They also do not appear to extend as far out in age as the dogs in our HCA sample. Also notable again is the lack of the dip near 8-9 years of age, suggesting that AKC registrations alone cannot account for the dip we see in our HCA survey.

Figure 7: Age Distribution of Living Havanese at the end of 2017

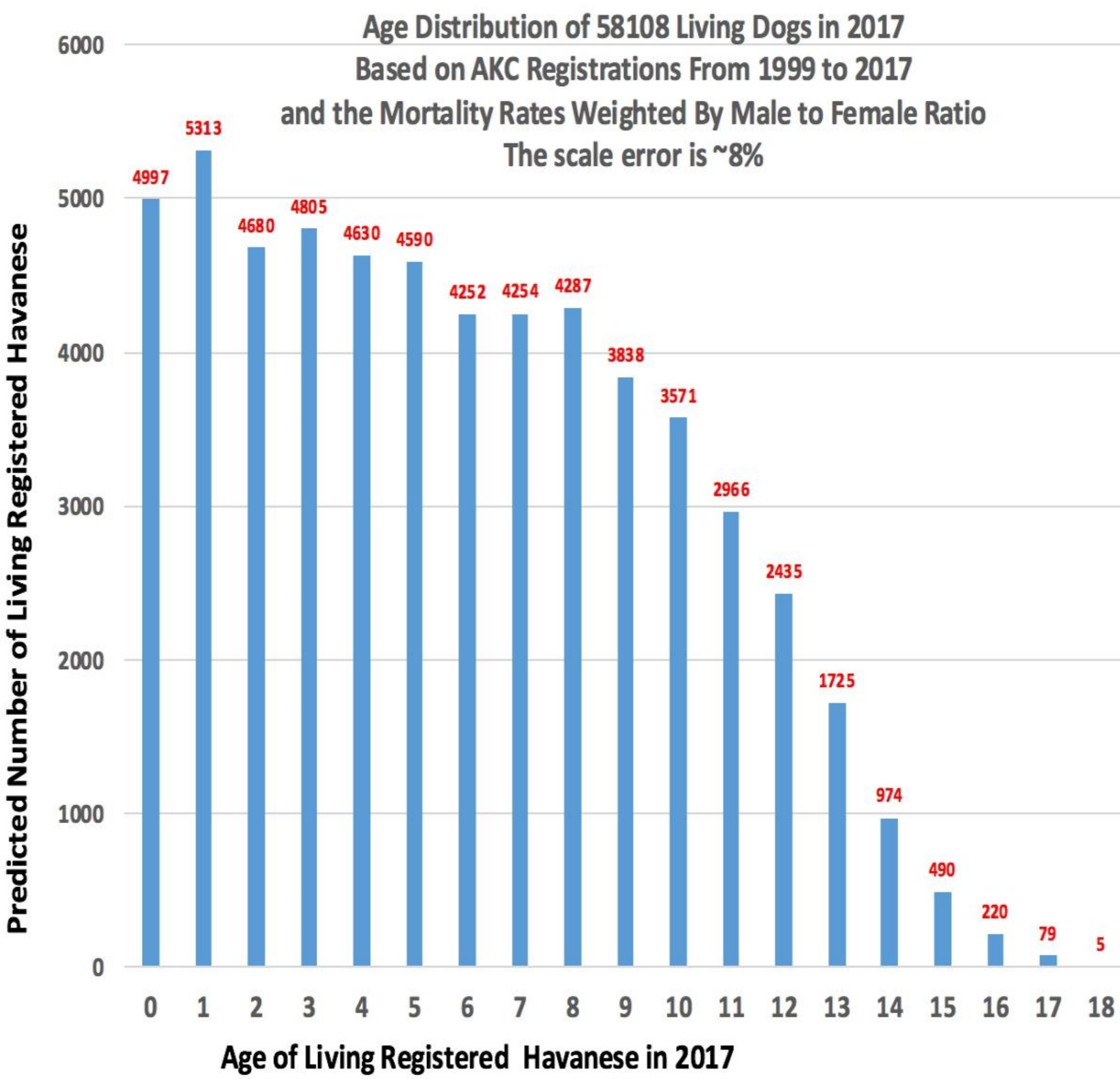
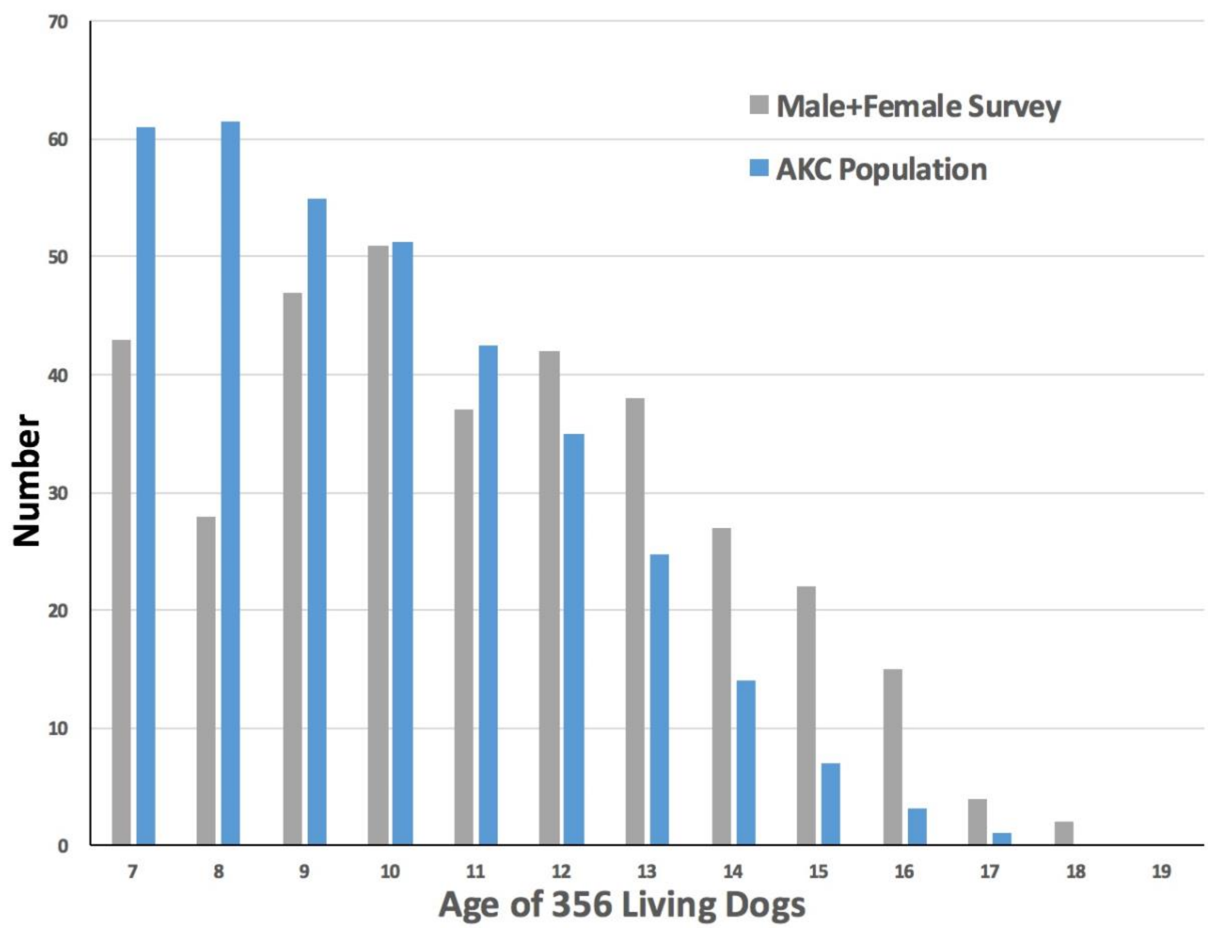


Figure 8: Comparison of Age Distribution of Living Havanese in the Longevity Survey and the Predicted AKC Population



Acknowledgements

We would like to acknowledge the help of Jane Ruthford in securing information from the AKC on breed statistics, in particular the breakdown of males and females. Jane is our AKC representative for the HCA and a member of the HCA Board of Directors in 2017.

We would also like to thank all the members of the Health Committee who recognized and supported this survey as a means of setting the groundwork and direction for future studies of our breed's health.