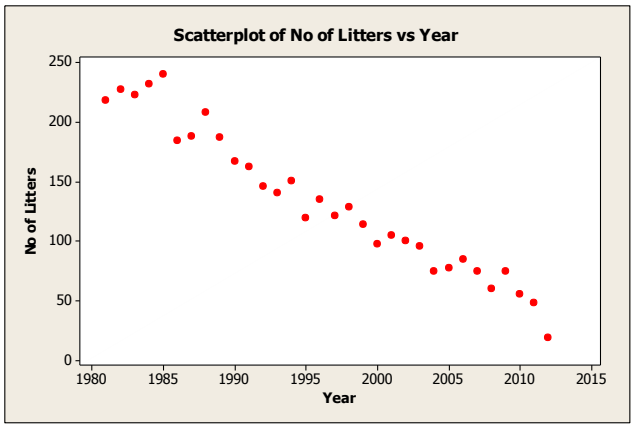
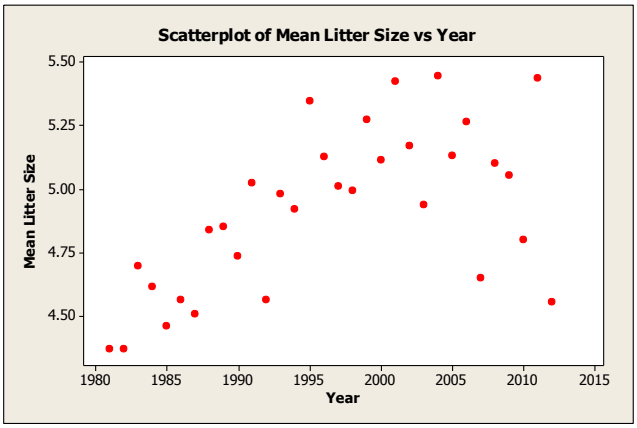
Inbreeding in English Setters

In view of the serious decline in numbers of English Setters being registered with the Kennel Club, and its consequent addition to the list of breeds regarded as being 'at risk', I offered to look at recent litter data to see whether there was any evidence that inbreeding might be playing a part in the apparent decline in fertility, and perhaps the survival of newborn puppies. .A few months ago, I asked for breeders to send me complete records of their litters: in particular, the name of the sire and dam, the date of birth of the litter, the number of puppies born alive and the number surviving to registration age. I received help from the following breeders (listed in alphabetical order): Lois Buckley, Jane Dennis, Fran Grimsdell, Linda Harris, Chris Jennings, Heather Lenzi, Simon Pitts, Lesley Stearns, Linda Taylor, Andrea Walker, Ingrid Young with a total of 225 litters. For convenience and brevity, I refer to these individuals as 'the breeders' although everyone who registers puppies with the KC is of course a breeder.

A note on terminology. When I write 'dog', I mean an English Setter of unspecified sex. I will write about 'male' and 'female' when referring to individuals of that sex, and 'sire' and 'dam' for the father and mother of a litter.

First, is there really a problem? Well, yes. The graph below shows the number of litters registered with the Kennel Club (KC) each year since 1980. Clearly, there are many fewer litters being registered than before (note that the point for 2012 is only based upon the first six months). The second graph shows the average number of puppies registered from each of these litters. Not such a clear pattern, but it looks like litter size increased up to about the year 2000, since when it may (*__may__*) have declined a little. There is anecdotal evidence suggesting that the number of unsuccessful matings has also increased recently – though this is harder to quantify.





So, the number of litters has declined and presumably also the number of animals in the breeding population (the 'gene pool'). Is all (or part) of the possible decline in litter size and increase in 'missed matings' associated with this reduction of the gene pool?

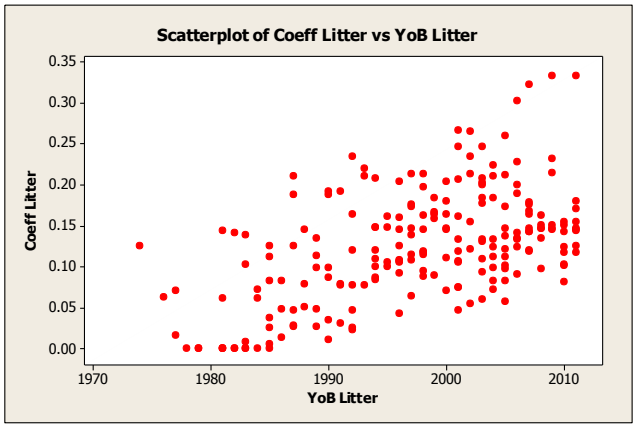
Now a word about inbreeding which is brought about by the mating of related individuals. The problem with this is that it can lead to the production of abnormal individuals through the coming together of copies of the same affected gene. It can lead to loss in fertility, vigour, health, growth rate and many other characters (known loosely as 'inbreeding depression'). However, it is not ***always*** a problem: there are plenty of examples of plants and animals that have undergone generations of close inbreeding with little or no adverse effects. Park Cattle and Darwin's Finches are examples of this. Conversely, in a famous example from adders, an isolated population in Sweden was undergoing serious decline: litter size was falling and mortality was high. A few males were introduced from a nearby population and the problem was resolved: litters improved and numbers rose. After a few (presumably happy and fulfilling) summers, the surviving males were returned to their native population! The decline in English Setter fertility is compatible with inbreeding depression – but is there any hard evidence that the two are causally linked?

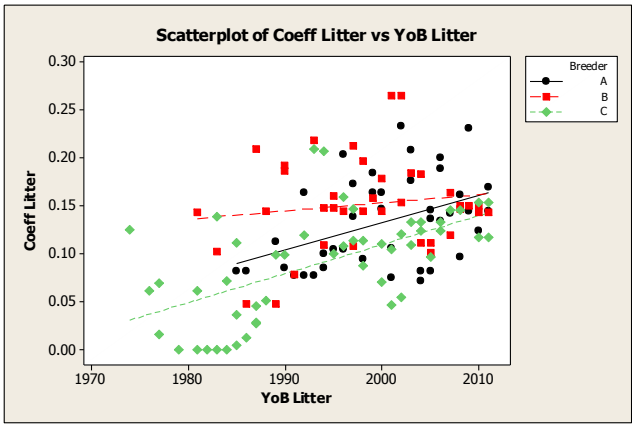
Inbreeding is estimated by the 'inbreeding coefficient' which is (more or less) a measure of the relatedness of the parents of an individual. This ranges from zero to one, where zero means that the parents were utterly

unrelated, and one means that they are genetically identical – as in identical twins. The more closely related are two individuals, the higher will be their offspring's inbreeding coefficient. A brother-sister mating will return an inbreeding coefficient of 50% (usually represented as 0.5), even if their own parents were quite unrelated.

Thinking about this for a moment, we all have two genetic parents, four grandparents, eight great-grandparents, and so on. If we go back 40 generations (a thousand years of we assume 25 years for a human generation), we each have over 40 billion ancestors – probably more humans than have ever existed. Clearly the same individuals must occur repeatedly in our ancestry: we are all inbred to a certain extent. Because a geneticist cannot know the relatedness of 'new' individuals, it is conventional to start any analysis of inbreeding by assuming that the parents are unrelated – we have to start somewhere. Thus, the earliest dogs in the KC register come back with a coefficient of zero. For example, the earliest English Setter male in the database given to me by the KC is *Thrumall Bachelor Boy* (born on 13 June 1971) and the earliest female is *Rivermark Hera of Valsett* (19 August 1973). The KC has no record of these dogs' ancestry on their computer, so they are given coefficients of zero. This does not mean that there was not some level of inbreeding in their ancestry. Of course there was. We just don't know what it was, and must give them this as a starting value.

Back to the data from the breeders listed at the top. Using the Kennel Club facility *Mate Select*, I was able to obtain the level of inbreeding for each sire and dam, plus the litter itself. If I plot a graph of the inbreeding coefficient of every litter against its year of birth, there is an obvious increase (below left). To make this picture a little more clear, the second graph shows the same information, but just for three of the bigger breeders. In each case, there is a progressive increase in the level of inbreeding over time. And, just to confirm this, the same holds for each of the 12 individual breeders listed above.

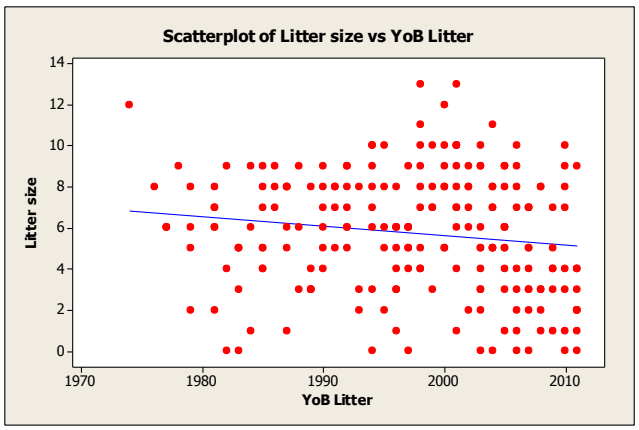


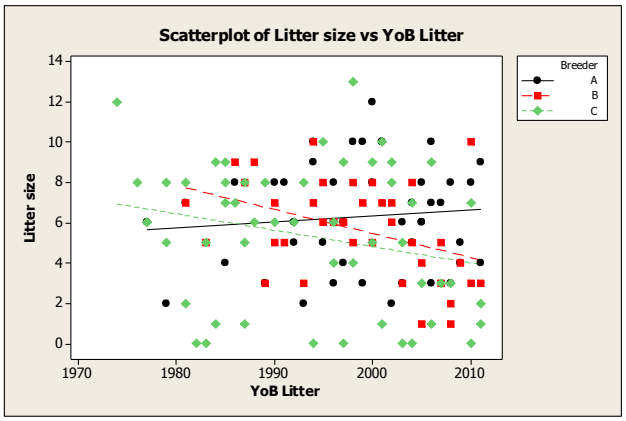


So, English Setters are becoming more inbred. Does this matter? Using the data from these 12 breeders, I looked at the number of puppies born in each litter since the 1970s. The graph below shows a modest decline – although it is 'statistically significant' (meaning that the decline is real and is not just due to chance). However, there is heterogeneity in these figures. If I again restrict the data to the same three 'bigger' breeders, it seems that B and C both have falling litter sizes, but that A's litters show a modest increase. However, the differences are marginal and cold be due to chance.

So, in summary so far:

- **The number of litters registered with the KC is falling;**
- **The number of puppies registered with the KC has declined slightly since about 2000;**
- **All 12 breeders who sent me data show an increase in the level of inbreeding within their stock;**
- **Overall there is a decline in litter size.**



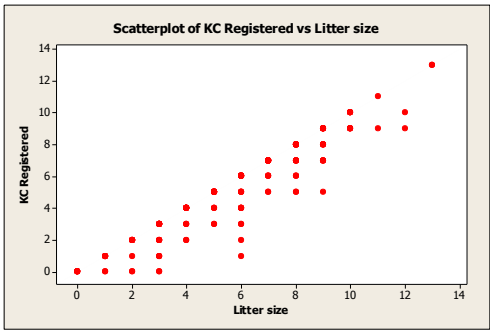


Turning now to look at the data relating to litter size. As well as the breeder and the year of birth, I also looked at the age of both sire and dam, and the inbreeding coefficients of sire, dam and litter. Unsurprisingly, in view of the earlier results, the year of birth has an effect: nine of the twelve breeders show a decline – although some of these are only modest. Otherwise, only the age of the dam has an effect: among these breeders, the age of the sire and the levels of inbreeding (of sire, dam or litter) show no association with litter size. It seems that (among the litters from the breeders listed above), older females generate smaller litters. This result holds for both the entire data set and when I restrict the data to the three bigger breeders. However, within the restricted data set, the inbreeding coefficient of the litter also reaches significance, with a negative correlation between litter size and the level of inbreeding of the litter. So, the 'take home messages' from the breeders' data seem to be:

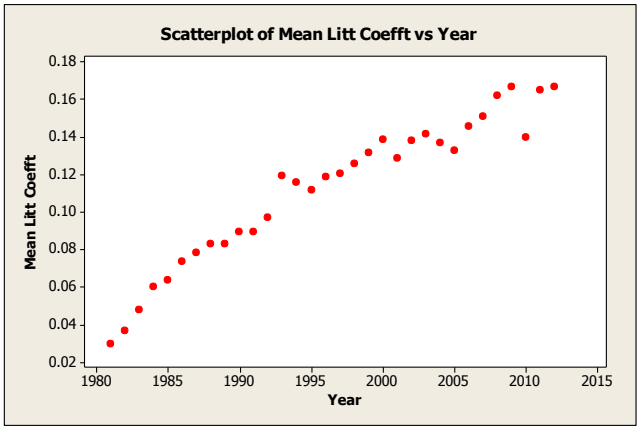
1. **Older bitches tend to have smaller litters.**
2. **The age of the sire and the level of inbreeding of the sire and dam are not especially important, but (within individual lines) the level of inbreeding of the litter may be.**

The former of these is perhaps not surprising: female fertility declines with age. The latter ought not to be a surprise either. While both male and female fertility might be associated with the degree of inbreeding of the individual involved, the actual viability of the embryos is more likely to be related to their own level of inbreeding. It would be very interesting to be able to look at those matings that 'missed'. I tried this with the breeders' data but there was no evidence of a difference in the level of inbreeding between those matings that failed and those that produced at least one puppy. However, the number of 'missed' litters is small (16) and most were from one breeder – not because they were less successful, but because their records of 'missed matings' go back further. I think that this is an avenue that deserves further examination (see below).

I then looked at all of the records of English Setters from the KC database. A problem with these data is that the litter size in the KC database is actually the number of animals registered (rather than the number born). While there is a correlation between these two figures, they are not the same. The graph below shows the data for the breeders who responded to the survey: unsurprisingly, more puppies are registered from bigger litters! Although there is no evidence that puppy survival is related to the levels of inbreeding, there is a suggestion that puppies are more likely to die if the female is older. This result is not strong, however, and in general factors other than inbreeding or parental age seem to be influencing puppy survival – at least among these breeders – although I must stress once again that numbers are small.

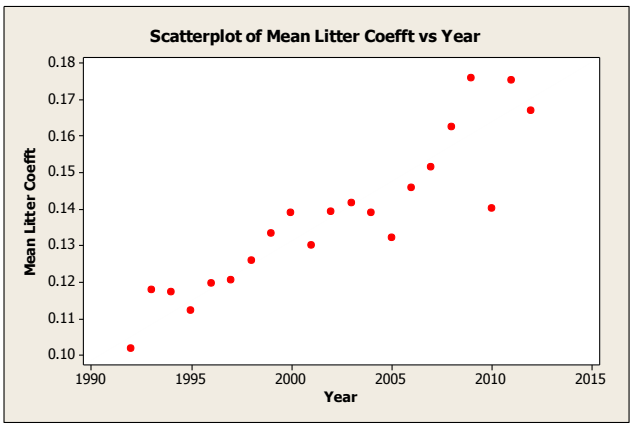


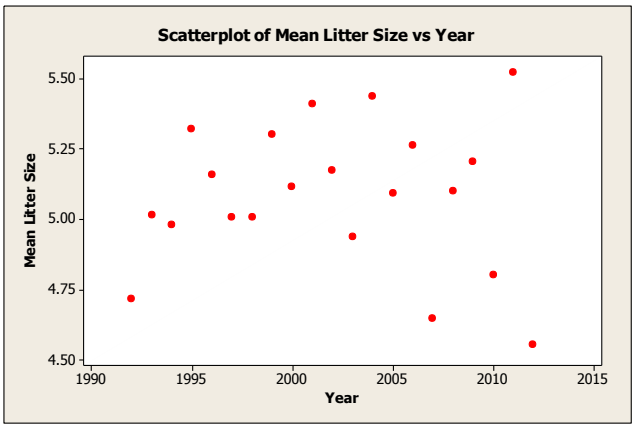
Returning to the KC database, I omitted 'working' dogs from further analysis since these breeders frequently do not register all of their puppies. This left 4274 litters up to June 2012 and (just as with the individual breeders) there is a clear increase in the level of inbreeding down the years. Bear in mind, however, that the first dogs were given scores of zero, and this will lower the average for earlier years.



For a variety of reasons, I restricted the rest of the analysis to litters born in or after 1992. Firstly, this covers the period when there may have been a decline in litter size. Secondly, in the earlier days, while many breeders registered their entire litters, others did not. Thirdly, after this date, every sire, dam and litter had a non-zero inbreeding coefficient, so the ancestry of each is known fairly accurately. This still left 1,953 litters. From here on, 'litter size' refers to the number of puppies registered.

As before, there is a significant increase in the inbreeding coefficient of sire, dam and litter over time (the graph shows this for litters). This graph is not as marked as the one immediately above with odd points (e.g. 2010) somewhat at variance, but the trend is still very clear. The decline in litter size is not as marked here – partly because of an apparent surge in 2011. In fact, I begin to wonder at this point whether a decline in litter size is more apparent than real?





The number of puppies registered from these 1953 litters are as follows:

Litter Size	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
No. of Litters	196	174	189	246	257	270	261	202	98	44	11	3	2	1953

I separated these into small (less than 6 puppies) and large (more than five puppies) litters, and looked for differences in parental age and inbreeding. Sires of larger litters were marginally older than those of smaller ones, while dams were marginally younger. However, these differences are small and could just be due to

chance. Much more striking differences emerged when I looked at levels of inbreeding. Coefficients of sires, dams and litters were all higher for small litters. The differences for dams were marginal, but those for sires and litters were 'statistically significant' – i.e. they are unlikely to be due to chance. However, there is some correlation between the levels of inbreeding. In a closed population (like English Setters), a sire that is himself inbred is more likely to produce inbred puppies. Looking at this in a little more detail suggests that it is the level of inbreeding of the sire himself that is important – the inbreeding of the litter may be more of a consequence.

	Age of Sire	Age of Dam	Sire Coefft	Dam Coefft	Litter Coefft
Small Litters	**4.56**	**4.26**	**0.147**	**0.132**	**0.150**
Large Litters	**4.67**	**4.16**	**0.132**	**0.125**	**0.139**
Difference?	**No**	**No**	**Yes!**	**Yes!**	**Just**

The results from the breeder survey and the KC database differ in several points. Evidence from the breeders suggests that it is the age of the dam that is important in determining litter size; the levels of inbreeding are less critical. On the other hand, the more extensive analysis suggests that parental age is less critical, but that the levels of inbreeding of sire (and perhaps) the litter may be relevant. Why should these results differ? It is possible that the reason lies in the fact that the three main breeders in the survey have practiced fairly intense 'line breeding' for many years. This selection may have eliminated some of the deleterious genetic factors from their stock. It is interesting that when I examined the KC data for other 'line-breeding' kennels, I similarly did not find any evidence that inbreeding played a part in litter size. Note though that the KC data relate to number of registrations – and not the number of puppies actually born.

The general conclusions are:

- **Intense line-breeding increases the level of inbreeding, but this does not necessarily have an adverse effect upon litter size.**
- **In general, using inbred males may reduce the size of any resulting litter.**
- **Similarly, litters that are more inbred are likely to be smaller.**

Recommendations:

- **When choosing a potential stud-dog, check how inbred he is; if you have a choice of several males, prefer the less-inbred individual.**
- **Use *Mate Select* to estimate how inbred the puppies will be; again, all things being equal, prefer a mating that will reduce this.**
- **However, you are breeding English Setters and not Inbreeding Coefficients; other characters (such as temperament, skin, hips, etc.) are also relevant.**

A final note. One thing that I have not really been able to examine is the proportion of matings that 'miss'. Obviously, if no puppies are produced, then the KC has no record of the mating. In view of the anecdotal evidence that missed matings are on the increase, it may be worthwhile attempting to gather data about this? A possibility might be to set up a (perhaps confidential) central registry of matings. When a mating takes place, the breeder (presumably the bitch owner) would register this as the names of male and female, the date, number of matings (perhaps with length of tie?). The outcome of the mating could be added subsequently – failed mating, or if successful, the number of puppies born alive and dead. Similarly, the number of puppies surviving to registration age could be recorded. Over the course of two or three years, enough matings might accumulate to allow a further analysis to be undertaken. The advantage of this would be firstly that it would include 'failed' matings, secondly that it would give a better picture of puppy survival, and thirdly that it would be a 'snapshot' of the current situation. This is a matter for English Setter breeders to decide among themselves. I would be comfortable with acting as a confidential 'store' for these data, and could report back to the Health Committee as the results came in. It is important to note, however, that incomplete or erroneous data would be damaging to the study and (ultimately) the breed.

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