

C.O.I.

The Coefficient of Inbreeding

By Lisa Dubé Forman



The science of canine husbandry can sometimes be overwhelming to many fanciers, both rookies and veterans alike. There are many technical considerations that factor into breeding that can confound the ordinary person. These include, the coefficient of inbreeding (COI), coefficient of relationship (COR), ancestor loss coefficient (AVK), pedigree collapse, inbreeding depression, formula approach, genetic diversity, genetic drift, and genetic loads. By and large, a fancier plans a litter with much anticipation and excitement, for perhaps, waiting in the wings, is the next sublime specimen — one slated for greatness in the wolfhound dog world. A method of approach that on the outset may sound glib, but it really is just an honest assessment as one of the compelling reasons why breeders create is to perfect, enhance and build on a breed. The better part do not wish to worsen or diminish the breed.

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The average breeder must understand these aforementioned technical considerations, yet, regrettably, they do not. Modern day breeding programs are based on regular appearances of significant names in pedigrees which itself is based on an ideological nineteenth-century attitude that still has a firm foothold in mainstream practices of canine husbandry. Breeders should not proceed with rudimentary information that originated from social attitudes instead of science. Even more, there is the impracticable method of basing decisions on only five generation horizontal pedigrees as sufficient evidence of the coefficient of inbreeding (COI).

Let us get right to it and begin with a few quick, simple definitions. ¹**Consanguinity** — blood relation — is the quality of being descended from the same ancestor as another hound. The **Coefficient of Relationship (COR)** is a measure of the level of consanguinity between two given hounds. To illustrate a COR, I will use my hound Ballyhara Cinneide. Her COR with Gartha of Ambleside is 19.10 percent as Gartha appears 714 times through the 13th and 20th generations. Next, a **coefficient of inbreeding (COI)** is a calculation for a single individual measuring the amount of pedigree collapse within that individual's genealogy. **Pedigree collapse** is the reproduction between two individuals sharing an ancestor, which in turn causes their offspring's number of distinct ancestors in the family tree to be smaller than it could be otherwise. In short, the higher the COI, the higher the amount of pedigree collapse effecting diversity which we discuss next.

While cultivating our hounds, we must bear in mind consequential points. One is that inbreeding and linebreeding are variations of the same principle, with linebreeding *only* a weaker form. Inbreeding, to be clearer, is a reproduction from the mating of pairs who are closely related genetically. Depending on the breed or species, some geneticists consider the appearance of common ancestors in the first four or five generations as being inbred. The reasons why are coming up. Another necessary term is **homozygosity** that technically is breeding true for a corresponding characteristic across the entirety of the dog's hereditary information. To simplify this definition, genes come in pairs called alleles, and if these two genes are identical then they are homozygous. The more identical or homozygous gene pairs, then there is less diversity. If the gene pairs are not identical, they are called **heterozygous**, and we have more diversity, which is favorable.

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Thus, ² COI measures the probability of homozygous gene pairs due to an identical gene being passed down to the hound along both the dam and sire lines from single common ancestors. Wolfhounds are a Founders breed subjected to several bottlenecks since its resuscitation. Therefore, it is an exceptionally homozygous breed as a direct result of having just a few common ancestors. Consequentially, inbreeding increases homozygosity that, in turn, increases the chances of offspring being affected by recessive or deleterious traits. In general, this leads to a decreased '**biological fitness**' of a population, called **inbreeding depression**.

First and foremost, 'fitness' is not defined or interpreted as physically being in shape nor athletic. Fitness is central to evolution and population genetics because the fitness of a population depicts the ability to both survive and reproduce. Decreased fitness of a population is a consequence of offspring affected by recessive or deleterious traits as explained above. Decreased fitness is due to mankind's intervention with nonrandom matings or artificial selection whereas Mother Nature works differently. Charles Darwin coined it as **Natural Selection**. ³Natural selection converts differences in fitness into changes in allele (gene pair) frequency in a population over successive generations. Small differences in fitness are sufficient to make large differences to a species evolution. In short, higher levels of fitness equals survival.

High coefficient of inbreeding (COI) percentages and reduced genetic diversity causes increasing hereditary diseases and defects. ⁴There is abundant evidence of such deleterious effects in numerous animals (and even plants) such as reduced fertility, greater infant mortality, shorter lifespan, diminished resistance to disease, and increased incidence of genetic diseases. We base COIs on a known pedigree, with 'known pedigree' as the operative words. A modern movement today, wolfhound hobbyists use the restricted, traditional five or even ten generation pedigree to establish the measure of a wolfhound or a litter's COI. In my opinion, this is hazardous. Cautious, informed hobbyists review known pedigrees extensively, 20 or even 30 generations if possible within their pedigree database program. Reviewing a reduced number of generations is a faulty custom that conceals the hound's factual state of inbreeding. Hobbyists are using a too small amount of data to determine COIs. It is a mathematical truth; statistical information is more and more accurate the bigger the data or sample size.

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Keeping abreast of general discussions today, supposedly many hobbyists are boasting breeding a hound with low COI, e.g., 2% or 5%. After investigating further, we discover that these unbelievable numbers are just that — unbelievable — as they are calculated on insufficient generations. A number of these hobbyists are not aware of the inaccuracies for their hound's coefficient of inbreeding. Others refuse to accept the truth, preferring not to perform or produce diligent calculations for the amount of pedigree collapse within their hounds' genealogy. Perhaps it is a small measure of peace for them. However, larger data samples show this breeds' probability of effects -- due to inbreeding -- is significantly greater since it has had several bottlenecks.⁵ Another possible reason for denial is that breeders do not trust genetics. People tend to be disbelieving while placing high importance on small amounts of data. Statistics are successful at predicting tendencies and correlations in large samples, but not so much in small ones. The bottom line is that human beings are bad at estimating probabilities because they are so counter-intuitive, and we vastly overestimate our deductive abilities when confronted with a small sample. Often, this bias is applied to the science concerning inheritance of genetic traits. Typical breeders' data, often consisting of the number of dogs in their breeding program is far too small for the laws of statistics to allow for accurate predictions. The fact that some breeders observe statistics that stand well apart from the expected is not evidence that the science of genetic knowledge, based on large number of cases, is wrong.

A standard depiction for the coefficient of inbreeding includes a number such as COI(5). The (5) indicates that the measurement of inbreeding was calculated on five generations only; it does not calculate the consanguinity of deeper ancestors. Many wolfhound fanciers proudly display a COI but rarely include the identifying number. Let us consider a coefficient sample for "Hound A" whose COI(5) is reportedly only 3 percent. However, in contrast, his COI(10) may reveal the number being closer to 30-50 percent. The results are significantly higher because of the 1,024 ancestors in his 10-generation pedigree; there are related matings after the 5th generation. The 6th through the 10th generations may reveal numerous appearances of a popular sire and his widely used offspring. It also uncovers other repeat ancestors who have 'fallen off' the standard five

C.O.I.

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generation, horizontal pedigree. As such, the total number of distinct ancestors in his family tree are much smaller than it could be otherwise.

⁶Calculating inbreeding for only the first few generations is not particularly useful. If there are more than one or two common ancestors in a four or five-generation pedigree, the inbreeding is probably already higher than desirable. Unfortunately, having none is no guarantee that common ancestors will not occur in abundance further back, and some pedigrees of this type still achieve moderately high inbreeding coefficients. Neither can the number of shared ancestors be used as a reliable guide, as the inbreeding coefficient is very sensitive to when and where they occur in a pedigree.

The coefficient of relationships is the significance of an ancestor(s) who may be making major genetic contributions to the hound in question. Particularly, if they appear in multitudes as is common in many Wolfhound pedigrees that include popular sires. Additionally, the COR will rise or fall according to how many times the ancestor saturates the earlier generations. For example, Hound A and Hound B may not have the same COR for Sanctuary Rory of Kihone because, in Hound A, Rory appears 7,046 times in the minimal 14th generation through the maximal 24th generation. In Hound B, Rory's appearances are further distant appearing 7,046 times, but much closer in the minimum 10th generation through the maximal 20th generation. ⁷COI calculations are meant to predict the level of homozygosity or doubled up alleles in a hound, due to the same ancestors showing up multiple places in the pedigree. This level of homozygosity is important because doubling up on alleles in the dog occurs, even if one chooses to ignore more distant generations. The more generations looked at, the closer the calculation will approximate the real level of inbreeding present in the dog.

8

Generati on	1	2	3	4	5	6	7	8	9	10
% of Genetic Contribu tion	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.195	0.098

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In theory, mathematically the genetic contributions of an ancestor are calculated in conformity with the generations in the above Table. However, it is necessary to note that the average Wolfhound's family tree (a breed that is marked by several bottlenecks and founders) has a collection of names appearing 50 times or more in their immediate generations. Indeed, in many pedigrees this real-time calculated number is a gross understatement. To illustrate ancestral contributions: Hound B (a real wolfhound) with an old bloodline pedigree not subject to today's bottlenecks has a 6.3% COI(5) -- five generations. His COI(30) -- 30-generations -- is 30%, a remarkably low figure considering we know true COIs for nearly all Wolfhounds. In this hound's 30-generation family tree, ancestor Sanctuary Rory of Kihone appears 7,046 times between the 10th and 20th generations. Rory's coefficient of relationship (COR) is 46.54% that is his direct measure of shared ancestry with Hound B. This COR percentage unveils how significant ancestors can make major genetic contributions, and COR percentages can be *very* surprising. Why, because genes are individual pieces of information that cannot be indefinitely diluted.

The total percentage of COR for each repetitive ancestor can be manually calculated for just a few generations if a hobbyist does not have a pedigree program. However, it is tedious. To calculate the COR for significant ancestors in more than five generations, it will require a computer program with enough data available for all ancestors. Manual COR computations for and in immediate generations of shared ancestors can be achieved by the following. Begin with the Parents as the 1st generation and multiply the number of times each ancestor appears in any generation by the appropriate percentage for that generation (*Use the supplied Table for the proper percentage of contributions.*) To illustrate: if ancestor Spot appears five times in the 3rd generation, then multiply 5 X 12.5 percent. Continue for ancestor Spot in every generation his name appears. Finally, add all of the calculated percentages of contributions from *each* generation to review Spot's total percentage of his genetic contribution.

Some fanciers who played a role, unwillingly or not, in this breeds' recent impending bottleneck have discussed options to lower their COIs and or dilute the unfavorable genetic material in their bloodlines. They believe dilution is a solution. Their plan uses a

C.O.I.

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linebred or outcrossed wolfhound, reportedly 'unrelated' to theirs, which they presume will moderate or water down their pedigree and its harmful genetic material. There are a few, simple logical challenges to this hypothesis.

- *First, there are no outcrossed wolfhounds in the modern database — barring any contemporary breeder crossbreeding with a closely related breed without everyone's knowledge. Bear in mind, the wolfhound breed originated from a few founders and has been subjected to bottlenecks, several times.*
- ⁹*Secondly, it bears reiteration that linebreeding is simply a weaker version of inbreeding (see my published article Ignorance is Not Bliss).*
- ¹⁰*Genes are individual pieces of information that cannot be indefinitely diluted.*
- ¹¹*All gene pools, no matter how large or diverse, will have a genetic load. In a closed gene pool, the situation may remain stable or deteriorate. It cannot get better.*

Moreover, a one-time shot of using a linebred or distant related hound is not the solution in a breeding agenda. We cannot water down genetic material in a highly inbred line by only incorporating a distant linebreeding once. If one were to use such a distant related hound, then he must be well integrated by the breeder. If not, there is likely to be little improvement in the overall genetics of the breeding program. To illustrate, we need look no further than the Basenji breed. Geneticist ¹²Carol Beuchat, Ph.D., detailed the Basenji breeds' coefficient of inbreeding (COI) from its introduction in the US, up through the 1990s. In the late 1980s, the Parent Breed Specialty Club petitioned to open the official AKC Stud Book and a handful of dogs were imported from Africa and added to the official Stud Book. According to Beuchat, prior to this integration of African blood, the 1979 Basenji populations' COI was an average 30%, with many dogs above 40%. However, even after the union of African bloodlines, the results from her 2012 COI graph were troubling. Despite combining these bona fide outcrosses from Africa in the 1980s, the majority of Basenji COIs in 1990 were still 20-40%, with many up to 50%. Sadly, a great opportunity appears to have been lost because there was an insufficient assimilation of the African stock into breeding programs and ultimately, into the Basenji population. Hence, the Parent Breed Specialty Club had to petition to open the official Stud Book again on or about 2008 to combine additional African stock. Putting this COI data into a frame of reference so that novices

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and veterans may understand and hopefully appreciate, consider that a full-sibling or father / daughter mating has a 25% COI. Parenthetically, take into account the following: Conservation geneticists working with endangered species estimate a COI of 5% as a cause for concern. A 10% COI is the level at which a species is in serious peril of extinction as a consequence of inbreeding.

During my research, I had the valuable opportunity to discuss the Irish Wolfhound's coefficient of inbreeding with the genetic researcher, Dr. Silvan Urfer, DVM. To an exceptional degree, we concentrated on the trend of computing COI based on only five or ten generations. We examined the limitations of ancestral genetic contributions pertaining to the use of extensive 20-30 generation pedigrees and that genetic material becomes heterogeneous, diverse in character or content through the generations. We covered the definition of Founders and their influence on the Wolfhounds' coefficient of inbreeding levels. Likewise, our dialogue included Dr. Urfer's thoughts on several suppositions and articles authored by Dr. Mike Tempest, a columnist for Dog World UK, particularly those on coefficient of inbreeding.

Upfront, Dr. Urfer stated that there are arguments in favor and against using a defined number of generations versus all known generations in COI calculations. That is to say, reviewing five generations versus 20 or 30. However, the chromosomes number representation, a preferred theory set forth by Dr. Tempest, is not an applicable argument, according to Dr. Urfer. The wolfhound population has grown exponentially since about 1965, which hides this breed's actual inbreeding. The actual COI calculation is not complete unless it is reviewed all the way back to Captain Graham. The issue is that various wolfhound breeding programs are much more populous than others. As a result, depending on how many litters or generations a constant breeding agenda produces, the research could require an extensive span of generations to find Captain Graham's hounds. Conversely, there is a handful of breeding programs today whose pedigrees reveal Captain Graham's hounds in as few as 19 generations or Cotswold and Wargrave in the 18th generation. Nevertheless, Dr. Urfer has yet to find an IW with a complete pedigree whose inbreeding coefficient is below 30%, nor does he believe this is possible. In his opinion, there is no particular scientific reason to use just ten

C.O.I.

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generations to calculate inbreeding; thus it may be a purely arbitrary usage that can be misleading.

An accurate representation of a wolfhound's inbreeding calculation must reflect the number of bottlenecks. Dr. Urfer expounds on this by adding that, under normal circumstances, we would have a random array of ancestors, and which exact genes we are inheriting from them would be random, as well. However, when they come from one ancestor, which we call a bottleneck, then the inherited genetic makeup of that ancestor is no longer a variable but a constant. Bear in mind the ¹³principle that genes cannot be created; each breed can only use the genes that were present in the foundation animals. In this case, we can certainly consider the early bottlenecks as founders due to their contribution of constant genetic material through their widely used progeny.

In consonance with Dr. Urfer, the definition of 'Founder' is quite tricky in itself because the breed has undergone multiple bottlenecks. Logically, a case could be made that all of Captain Graham's dogs with surviving offspring were founders, or even reasonably that Glengarry Deerhounds were founders. Nevertheless, succeeding bottlenecks took genetic variation with its random passing on of genes out of the equation. With this in mind, both Clonboy of Ouborough and Sanctuary Rory of Kihone could be considered founders as their offspring were frequently, but most importantly, widely used. Depending on the believed definition, the number of founders in the Wolfhound breed could be five, less than five, or dozens.

According to Urfer's comprehensive Irish Wolfhound research, for all practical purposes Sanctuary Rory of Kihone accounts for more than 25% of the breeds genetic variability. Clonboy of Ouborough represents 20%; Kevin of Ouborough (a bitch despite the name) is responsible for 10%, and Cragwood Barney O'Shea represents 8%. The conclusion and facts are that these four hounds account for 63% of the wolfhound breeds' genetic variability.

Going forward, what will contemporary wolfhound hobbyists do with this information? What of the coefficient of relationship (COR) computations of shared ancestors which Urfer believes is essential when reviewing ancestral contributions? Will

C.O.I.

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this trend of computing COIs based on only five or ten generations continue, especially in a breed who has just four hounds accounting for 63% of its populations' genetic variability? As "successor people" we must always keep in mind that our present is connected to the past. ¹⁴More information is always equal to or better than less information. Realistically, this is the only way we are to protect but importantly preserve this magnificent breed.

¹ "Coefficient of Relationship." Wikipedia, the Free Encyclopedia, http://en.wikipedia.org/w/index.php?title=Coefficient_of_relationship&oldid=572719606.

²<http://www.dogbreedhealth.com/a-beginners-guide-to-coi/>

³http://en.wikipedia.org/wiki/Population_genetics

⁴ "Do We Really Need New Basenjis?" Carol Beuchat. <http://www.carolbeuchat.com/2012/05/do-we-really-need-new-basenjis/>.

⁵Urfer, Silvan, Dr. DVM

⁶ "Significant Relationships." <https://www.dogenes.com/essays/relation.html>.

⁷ Christopher. "COI: How Many Generations Are Enough?" BorderWars. <http://www.border-wars.com/2011/10/coi-how-many-generations-are-enough.html>.

⁸ "Significant Relationships." <https://www.dogenes.com/essays/relation.html>.

⁹"Not Knowing is Better Than Knowing, Ignorance is Not Bliss!" Lisa Dubé Forman, <http://ballyharairishwolfhounds.com/published-articles/>

¹⁰ Urfer, Silvan Dr. DVM

¹¹ "The Downside of Inbreeding: It is Time For a New Approach." C.A. Sharp <http://www.dogenes.com/other/price.html>.

C.O.I.

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¹² "Do We Really Need New Basenjis?" Carol Beuchat. <http://www.carolbeuchat.com/2012/05/do-we-really-need-new-basenjis/>.

¹³ "ACC Population Genetics." Lisa Van Loo <http://www.amchessieclub.org/health/DNA/DNA3.html>.

¹⁴ Christopher. "COI: How Many Generations Are Enough?" BorderWars. <http://www.borderwars.com/2011/10/coi-how-many-generations-are-enough.html>.