

# Foundation Foxtrotter Heritage Association – Its Foundation is Weak

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# 1. Introduction

There are two versions of this document. This version which gives background details one needs to know to understand the basics of the genetics behind my arguments and a shorter version ([V-factor synopsis](#)) which is for those already familiar with basic Mendelian genetics. I apologize for the length of this document but there are many points to be made regarding why the FFHA's V-factor for a MFT horse is a number that carries no real meaning. The good news is that if while reading either this discussion or while reading the shorter version of it, you are convinced that there is not enough support to justify ever using the V-factor in your own breeding/buying decisions, you may stop reading and you may not have to read very far before you get there.

The Foundation Foxtrotter Heritage Association ([FFHA](#)) is a supplemental registry for horses that are registered in the Missouri Fox Trotting Horse Breed Association ([MFTHBA](#)) registry and also meet the FFHA's additional criterion for membership. The FFHA's stated mission, according to their [mission webpage](#), is to maintain a gene pool of original Foxtrotter blood. They promote the use of a quantity called the V-factor as their additional criterion for eligibility. Details of how a V-factor is calculated are not provided on the FFHA website although there is a page called [V-factoring](#) where many unsubstantiated claims concerning what is known about gait genetics are made. In addition, specific research studies that supposedly support conjectures made about gait genetics are not cited in the V-factor discussion but conclusions are drawn from what are claimed to be actual studies. If these studies actually exist, they should be documented with specific references in order to allow readers to verify for themselves what the findings of the studies were. Withholding the specifics about referenced studies casts doubt on the validity of any conclusions made by any author at anytime. Yet this is done repeatedly in the V-Factor discussion that is given on the [FFHA Vfactor webpage](#).

It is interesting to see how the reasons given for V-factoring have moderated over the years. The current form of the V-factoring document has been heavily edited compared to what was on the FFHA website in 2009. The [2009 V-factor document](#) made even more outrageous claims than are being made in the current document. No doubt that that document was revised several times because the author couldn't defend many of the assertions that were made. Nonetheless, I believe that document gives a more complete account of the basic beliefs of its author than does the most recent version which has been edited so fewer people will object to the claims that are still being made. My comments will refer to assertions made in the two versions of why V-factoring should be done. They both reflect the beliefs of their author.

# 2. Credentials

Before the discussion starts, I would like to state my credentials. I have advanced degrees in population genetics, sometimes called statistical genetics, from Michigan State University and I have done collaborative research with numerous researchers leading to over 90 [publications](#) in peer reviewed journals. I am a Professor Emeritus, I taught graduate level statistics courses, carried out research, guided graduate students for masters and Ph.D degrees, served on numerous graduate student committees, and was a consulting statistician for the Kansas

Agricultural Research Experiment Station for 39 years at Kansas State University. I have many years of experience of doing research and reporting the results.

### **3. Presentation of findings and credibility**

There are established protocols for presenting scientific results. Of course genetics is a biological science. Population genetics combines statistics and genetics and is not an area where laypersons can build the foundation of the knowledge needed on their own which would enable them to understand and interpret results from research projects that are presented in technical, peer reviewed journals. The topics described on the FFHA V-Factor page are in the realm of population genetics. When scientists draw conclusions from their own or other's research, they back up those conclusions by either citing specific references to the work done by others or they present details of their own research findings along with their data and statistical analyses of the data. This is done uniformly in science to ensure that an author writing from a certain point of view doesn't skew the interpretation of results to make them support, or seem to support, whatever his or her personal point of view may be. The V-factor discussion is written as if it were a discussion of scientific findings but it does not include specifics for any of the references made to existing research nor does it provide any details about the private research the author claims to have done. This approach casts serious doubts over the veracity and usefulness of the V-factor score that the FFHA bases its existence on. The procedure is ad-hoc, without any substantiation of its usefulness, and the cut off number used for admittance (128) into the FFHA registry is completely arbitrary and without any objective criteria as to why the value 128 was chosen.

### **4. Why we care**

You may wonder why we care about what the FFHA claims or whether their claims are valid. We care because we feel anyone just getting into the MFTHBA who may stumble upon the FFHA site should be warned about the lack of justification given for the V-factor before they accept the claims made about it or consider using it as a criterion in evaluating the quality of a Missouri Foxtrotter. We would like to keep the unwary from breeding to a horse or purchasing a horse that may be claimed to be something other than what it is. We also hope to prevent people from paying fees to join an organization and registering horses without full knowledge of what the precepts of the organization are and fully considering the validity of the ideas being put forth by the organization on their web site. The FFHA makes claims that are not corroborated by any objective scientific evidence. There is strong evidence that the author of the V-factor page does not understand the most basic principles of genetics. Claims are made that are direct contradictions to what little data are cited. Misinformation is used to convince the reader that there is scientific evidence that supports the idea of the V-factor being related to gait when in fact no such evidence exists. We do not want the image of MFTHBA registered horses to be damaged by an apparent relationship with an organization such as the FFHA.

### **5. Breed History**

It is important to understand the origins of the Missouri Foxtrotter (MFT) and Tennessee Walking Horse (TWH) breeds. Early gaited horses in America have similar origins that include: the American Saddle Horse, [American Saddlebred](#) (ASB), [Tennessee Walking Horse](#), and the [Missouri Foxtrotter](#), as well as others. The American Saddlehorse or "Saddle" horse preceded formal breed registries. It was the type of gaited horse that was developed in the south, sometimes called a Plantation horse, and was subsequently crossed with other types or breeds of horses to be part of the creation of new breeds. The Saddlehorses eventually became the American Saddlebred breed after being crossed with Thoroughbred and Standardbred horses to make them showier. The TWH registry includes Canadian Pacers, Narragansett Pacers, through the plantation horses, Thoroughbred, Standardbred, Morgan, and American Saddlebred in its origins. The Missouri Foxtrotter origins include the Arabian, Morgan, American Saddlebred, Tennessee Walking Horse, and Standardbred. It is evident that there is a lot of commonality in the origins of the Missouri Foxtrotter and the TWH breeds. It is also important to note that it is not uncommon for a horse registered TWH to have a fox trot gait. In fact, many such horses were included in the MFTHBA registry until the MFTHBA books were closed in early 1982.

## 6. Strength of Pace argument based solely on Standardbred horses

In the discussion of [V-factoring](#) that is given on the FFHA website an assertion is made early in the discussion that pace is over taking the gaited breeds. It is stated even more strongly in the 2009 version of the document. There are no data or examples given to backup this assertion. There is not one shred of evidence provided that supports such a conclusion. An Internet search did not turn up any hits when I searched on "pace gaited horse" and other similar search strings. It does seem that a problem as extensive as is claimed regarding run away pace in all of the gaited breeds would have generated discussions, complaints, or information on how to deal with it on the Internet at some point along the way (There is a good discussion of how to deal with a pacing horse written by Lee Ziegler that may be of interest to some readers: [Cure that Pace](#)). The discussion on the FFHA site goes on to say that pace had even effected the Standardbreds. The author does not give a specific reference for a study claimed to have been done in the late 1900's where crosses were made using trotting stallions on both pacing mares and trotting mares, and using pacing stallions on pacing mares. It is reported that a large majority of offspring paced from the cross of trotter-pacer, a substantial percentage paced from the trotter-trotter cross, and that 100% paced from the pacer-pacer cross. First, we have to question why the specific reference for the experiment is not provided. Second, what is the difference between a large majority and a substantial percentage and why weren't the actual percentages reported? The discussion goes on to say that it was **deduced** from this research outcome that **pace is stronger than trot**. We have to ask: "Deduced" by whom? The fact that the research is not cited so that anyone interested could read it and make their own interpretations and the fact that the phrase "was deduced from" is used to summarize the findings raises serious questions about what actual conclusions were reached by the scientists who did the study, assuming it was actually done. Furthermore, and most importantly, the fact that the crossing of pacers to pacers resulted in 100% pacers supports a conclusion that pace acts as a recessive genetic trait, yet the author of the V-factor concludes that the above results show that pace is stronger than trot. Clearly the author of the V-factor discussion does not understand the most basic concepts of genetics because the results given above are consistent with results that would be expected if trot is dominant to pace, or pace is recessive to trot, either way the indication would be that trot is

stronger than pace which is contrary to the misinterpretation given by the author of the V-factor discussion. Her conclusion is exactly the opposite of what the results support. This is a very important outcome because it is this study that convinced the author that pace is stronger than trot. It is not true and therefore the premise that limiting TWH blood will control pace in the MFT breed is without any foundation.

### ***1. Unique history of Standardbred breed and two groups of horses within it***

There are several pertinent facts that were not revealed in the brief discussion given. The Standardbred breed is very unique in a couple of important ways (Cothran, et al., 1987). The history of the breed goes back to 18<sup>th</sup> century and the origins include Thoroughbred, Morgan, Norfolk Trotter, and Canadian Pacer breeds. The early horses were trotters. The registry was established in 1871 with an admission standard of 2 minutes and 30 seconds for a mile at the trot. In the 1880's pacing 'blood' was introduced as a means to improve the trotting stock. The source of the pacers was Canadian Pacer. In 1891, 20 years after establishment of the registry, the standards were revised to include a pacing performance standard: a mile in 2 minutes and 25 seconds. The books were closed in 1973.

### ***2. Trotters and pacers in the Standardbred breed are from different origins***

It is very important to note that the origins of the trotting and pacing horses in the Standardbred breed were quite different. The trotters included some Canadian Pacer but it was mixed with three other breeds. Nonetheless, there are pacing genes from Canadian Pacers in the trotter origins. Another factor at play is that in this breed it is all about racing and speed. A horse has to either pace or trot in order to race. There was considerable crossing between the trotters and the pacers in the late 19th and early 20th centuries but since that time they have only been lightly interbred (Cothran, et al., 1987). Thus, even though these horses have been registered in the same registry for many years, they have been bred much more as if they were two separate breeds in the same registry most of that time. Their genetics reflect that they have not been interbred as are horses within almost all other breeds. It makes no sense genetically to generalize the results of the above study, or any other study done on Standardbreds, to trotters and pacers in the gaited horse population because no gaited horses, regardless of gaits, are registered in the same registry and bred as two separate breeding populations within their registry as are Standardbreds.

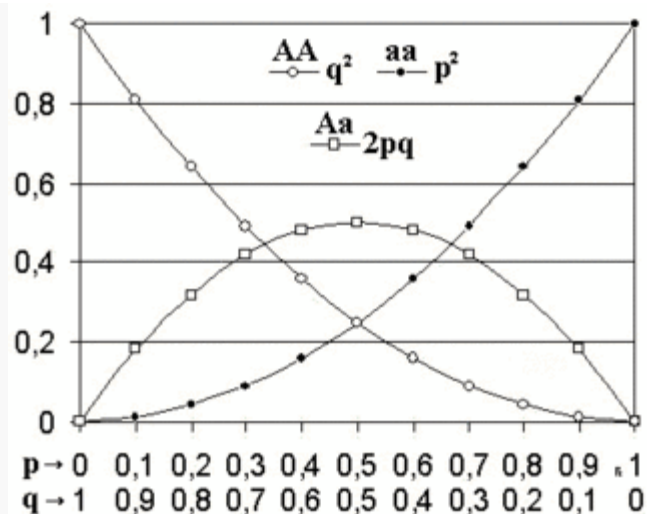
## **7. Question of data reliability**

It would be of interest to know how the data were obtained in the research that led to the deduction made by the author on the FFHA website as referenced above. It appears this study is a study other than the Cothran, et al., 1987 study. We need to know if the foals in this study were kept and raised by researchers and then evaluated at age two, three, or whatever age, by an objective expert as to what their natural gait was, or if the registry books were used to provide those data? We have to guess because the actual study isn't specified, but my guess is that it was the latter which means the data are based on how the foals were registered, either trotter or pacer. They were probably never evaluated by an objective observer, maybe not even by the owner.

Because the pacers are generally somewhat faster, we should be concerned that there may be a bias toward registering a horse as a pacer because it may be more saleable as such? If the determination of gait was based solely on how the horses were registered, which it probably was, the results would have to be deemed unreliable for estimating the proportion of foals that trotted or paced because their actual gait would not have been determined empirically.

## 8. Gene frequency basics

The author of the V-factor discussion seems to be unaware that there is a relationship between the frequency with which traits occur in the phenotypes of a population and the frequency of particular genes that occur in the genotypes of a breeding population. Consider the chart showing Hardy-Weinberg equilibrium ([Hardy-Weinberg](#)) which is reproduced below:



Hardy-Weinberg principle for two alleles: the horizontal axis shows the two allele frequencies  $p$  and  $q$ , the vertical axis shows the genotype frequencies and the three possible genotypes are represented by the different glyphs

The above chart shows the relative frequencies of genotypes for the case where a trait is determined by one pair of genes at one locus with two alleles. Of course gait inheritance is not this simple but the basic principle applies to more complex forms of inheritance as well. The details become a lot more complicated as the number of genes involved increases but the frequency with which a trait appears is always related to the frequency of the allele for the trait in a breeding population. Let us consider an example that shows the relative frequency of traits in offspring are affected more by the frequency of the alleles for the traits in the breeding populations than they are by the relative strengths of the genes for the traits. For simplicity, let us assume that gait inheritance is very simple, controlled by two alleles at one locus and that  $A$  represents trot and  $a$  represents pace. Let us also assume that trot is dominant and pace is recessive, meaning that if the genotype is  $AA$  or  $Aa$  the horse is a trotter (the trot gene is stronger than the pace gene in this example) and if the genotype is  $aa$  the horse is a pacer. In the above chart,  $q$  is the frequency of gene  $A$  (trot) and  $p$  is the frequency of gene  $a$  (pace). The chart shows that when  $q$  is 1,  $p$  is 0, meaning that  $a$  is not present in the breeding population at all as would be the case if there were a homogeneous group of trotters. The results on

the extreme left of the chart show that all offspring produced would be  $AA$  and under our assumptions all the horses would be trotters. As  $q$  decreases and  $p$  increases, the genotypes that include  $a$  become more frequent. Consider the case where the alleles are equally frequent at  $p = q = 0.5$ . This result is in the middle of the chart and the results are  $0.25AA$ ,  $0.5Aa$ ,  $0.25aa$ , which means we would have 0.75, or  $3/4^{\text{th}}$  trotters, and 0.25 or  $1/4^{\text{th}}$  pacers. To get results similar to those in the experiment that was alluded to in the V-factor discussion,  $p$  would be 1 in the population of pacers and perhaps 0.5 in the population of trotters. As the chart shows, when  $p=1$ , all the offspring are pacers when we cross pacers with pacers. When crossing trotters with trotters we would have the results given above, i.e.  $3/4^{\text{th}}$  trotters and  $1/4^{\text{th}}$  pacers. When crossing pacers to trotters, pacers would provide the  $a$  allele in all matings and the frequencies in the trotter population are assumed to be  $0.5A$  and  $0.5a$ , so there would be 50% trotters ( $Aa$ ) and 50% pacers ( $aa$ ) from those crosses. If we set the frequency of the pace gene,  $p$ , in the trotter population to a higher, say between 0.6 or 0.7 rather than 0.5, we would more nearly duplicate the results cited in the V-factor discussion. The point, a very important point at that, is that in this example, we assumed pace to be a recessive trait, meaning that it is weaker than the trot gene because when the trot gene is present in the  $Aa$  genotype the pace is suppressed, yet pacers are produced when trotters are crossed on trotters and relatively more pacers are produced when trotters are crossed on pacers, just as in the experiment from which it was "deduced" that pace is stronger than trot. The pace is occurring in the crosses in the above examples because of gene frequency effects not because of it being the stronger trait. There is no way that the results from an experiment that shows results similar to this example, which the study cited on the FFHA Vfactor webpage did, could be used to deduce pace is stronger than trot if one understands basic [Mendelian](#) genetics.

Recent research has shown that the dominant-recessive mode of inheritance may be similar to the way the ability to gait is inherited ([Andersson, Lisa S, et al.](#)). This groundbreaking research found that the presence of a mutant form of the  $DMRT3$  gene is necessary for a horse to be able to gait and that a horse must be homozygous for it to be able to pace. It is a permissive requirement for gait meaning that it must be present to allow a horse to gait but does not guarantee it will. The research also showed that the  $DMRT3$  mutant gene is very prevalent in gaited breeds and is completely absent in all stock horse breeds. Of course there are other genes involved in determining the gaits a horse can/will do, but the  $DMRT3$  mutant is clearly a major player.

Further evidence that gaiting tendencies are inherited in a recessive manner is provided by the Morgan breed. Although not originally a trait that was included in the breed standard, there are continually horses produced in the breed that do some sort of soft gait. The trait couldn't be bred out of the breed so they finally started registering "[Gaited Morgans](#)". The fact that a smooth gait kept appearing doesn't indicate it is stronger than trot, to the contrary, it shows that gaiting ability in Morgan Horses is a recessive trait which is often hidden by the presence of one or more dominant genes that encourage a horse to trot or discourage it from gaiting, however you want to look at it.

## 9. Misinterpretation of published research

### 1. Study details

Subsequent to the claim that "we know pace is stronger than trot", which we definitely do not, the author of the FFHA discussion makes reference to research done by Dr. Cothran using Standardbreds. Although the paper itself is not cited, I found the published results of the research and they are very different than what the author the V-factor purports them to be. The publication is: "*Genetic Differentiation Associated with Gait **Within American Standardbred Horses***" (Cothran, et al. 1987). Note that I emphasized the last 4 words in the title as they are extremely important regarding the implications of the findings of this research. They were totally and intentionally ignored and left out of the discussion presented about this research on the V-factor webpage. Cothran presented a summary of their findings in abstract form and reported that 20% of the offspring sired by trotters are registered as pacers and 1% of the horses sired by pacers are registered as trotters. Note the statistics show how the horses were registered rather than what their natural gait was. That was most likely the case in the study mentioned earlier as well. It may be the same study.

On page 286 of this article, second paragraph, the last sentence is: "*No formal analysis of the genetics of this complex behavioural trait has been undertaken; however, the tendency to trot or pace appears to be inherited (Lasley 1978).*" The last sentence of the third paragraph states: "*In the present study, we compare gene frequencies of trotters and pacers at 23 loci in order to obtain a better understanding of the genetic structure of the Standardbred breed.*" Clearly they are limiting the results and conclusions of this study to the Standardbred breed only and they clearly state that they didn't do any analyses regarding gait, they were interested only in the 23 marker loci which are not known to be related to gait. Furthermore they clearly said why they studied the 23 loci: "... to obtain a better understanding of the genetic structure of the Standardbred breed." They did not say it was to study the differences in horses that trot and those that pace in any general sense. The author of the FFHA website discussion clearly chose to intentionally mischaracterize the meaning of the findings from this research and did so quite blatantly.

### 2. Conclusions of the study's researchers

According to the researchers the above study was done in order to assess how effectively the two groups of gaited horses within the Standardbred breed have been genetically separated over the years up until the time of the study. *There was interbreeding of trotters and pacers early on in the breed but that was followed by very little interbreeding of the two groups thereafter.* The authors of the study estimated the frequencies of known genetic marker alleles in the two gait groups in order to see if the two groups were as similar as would be commonly found within other horse breeds or if they were more different than that. The genes that were studied were at 23 loci that have alleles that effect cell and blood serum proteins and some enzymes. No genes known to be associated with gait were included among the 23 markers. Horses that commonly interbreed, as is the case within most breeds, have similar frequencies of the blood marker alleles because there is no selection either for against them. The 23 pairs of alleles are dispersed throughout a breed in a random



fashion as a result of them being unknown and of no interest to breeders and they don't affect viability. The process by which a random pattern becomes established this way in a breed is known as random drift and the patterns are unique among breeds but similar among the horses within the same breed. The longer a breeding population is isolated, the more unique the frequency pattern among the 23 marker genes becomes because as time goes forward random drift changes the relative frequencies of the genes. Breeding populations that have not been separated for very long will have similar gene frequency patterns and those that have been separated for long periods of time will have less similar patterns. The conclusion reached in this study was that there were substantial differences between the two groups of horses within the Standardbred breed, more than what is usually found between random samples of horses within other breeds. This is not surprising given the unique history of the breed because of the different origins of the trotters and pacers within it from its very beginning. The question of interest is whether the marker gene frequency differences that exist between the two groups are due to their different origins and continued breeding separation or are they due to the fact that the horses carry different gait genes, or perhaps it is some of each. The authors did not claim to know the answer to that question based on this study. Here is part of what they concluded: Page 294, paragraph 2: "*The genic differences between Standardbreds of the two gaits may be historical in nature, a result of different origins of the trotting and pacing segments of the breed (Hervey 1947). If this is the case, significant gene frequency differences have been maintained despite considerable interbreeding during the formative period of the breed and in the face of continuing gene flow.*"

### **3. Conclusions on V-Factor webpage**

Here are the conclusions made on the [V-factor](#) webpage regarding this study: "*Dr. Gus Cothran of Texas A&M participated in a **study whereby geneticists were able to identify the difference between pace and trot at the molecular level. This was the first time science could substantiate a genetic difference between the two gaits. ...***" This is a gross misrepresentation of the results of this study. It showed no such thing. All it showed was that the pacers and trotters within the Standardbred breed had different gene frequency patterns for the blood marker alleles and the authors stated clearly they did not know if this was due to the history of the breed which includes the different origins of the trotters and the pacers and their ensuing breeding separation. The researchers' conclusion clearly allowed that it may be. Of course some differences in the frequencies of some of the marker alleles could be related to gait genes if they happened to be located at a locus near the locus of an allele that affects gait on the same chromosome. The author of the V-factor discussion failed to mention that the study was done on the Standardbred breed which puts a completely different light on the interpretation of the results when comparing the trotters and pacers. To say that the differences that were found in the frequencies of the marker alleles between the trotters and pacers within the Standardbred breed is the first time science could differentiate between the trot and pace gaits at the molecular level is to me an unbelievably misleading and biased way to state a conclusion. The author of the V-factor page concludes her summary of this research with: "***The results show there is as much difference between pace and trot as there would be between totally unrelated breeds. That is a very substantial difference.***" The V-factor author purposely makes it sound like this study established that trotters and pacers are as different as two different breeds, period. No qualifications given. The fact that this study was done within the Standardbred breed on blood marker genes and applies only to Standardbreds because their history is so unique, is intentionally never

mentioned. The authors of the research clearly pointed these facts out for the reader. This is not something that could have been missed. Ask yourself if the author of the V-factor discussion had the ability or the intention to correctly summarize the other studies that were mentioned in her discussion. She failed to interpret this study correctly even though the authors stated clearly what they did, why they did it, what the results were, made it clear that the study applied only to the Standardbred breed, and they drew appropriate conclusions themselves. The only reason she could have had for not giving a specific reference to this study, as is always done by scientists when reporting research findings, has to have been so she could impose her biased point of view on the findings. The results were misrepresented in order to deceive the reader into believing what she wanted the reader to believe. This is unethical behavior to say the least?

Not revealing that this study was limited to Standardbreds has even more significance than it may at first seem, not just because of the Standardbred's differing origins and their breeding separation but also because Standardbreds are not gaited horses. The term "Gaited Horse" is applied to horses that have one or more intermediate gaits, between a walk and a canter, other than an ordinary, 2-beat trot which is sometimes referred to as a hard trot. The trot is a rough riding gait because a horse leaps into the air to switch diagonal leg pairs as it moves forward. What goes up must come down and when it does, the rider is jolted. A pace is very similar except that a horse switches lateral leg pairs rather than diagonal pairs of legs as it leaps into the air and moves forward. Gaited horses' intermediate gaits always have at least one foot on the ground and that allows them to move forward without leaving the ground so there is much less vertical motion and much less bouncing for a rider. The running walk, stepping pace or amble, fox trot, rack and similar gaits in various breeds are called "soft gaits" because they feel smooth and riders do not suffer jarring like that of a normal trot or pace. The Cothran study could not have shown that soft gaited horses that fox trot and those that are more laterally or actually pace are vastly different genetically, because Standardbreds do not do any soft gaits. They have different speed gaits, either trot or pace, but they are not gaited horses. They are race horses. There is absolutely no evidence from this study that gaited horses that pace and those that trot or fox trot are largely different because not one gaited horse was included in this study. Of course anyone familiar with MFT horses already knows that horses that fox trot and horses that pace are not all that different. Many Foxtrotters do both gaits. The V-factor author would have us believe that the different frequency patterns in blood marker genes between the trotters and pacers in the American Standardbred breed, give evidence that the genes inherited for gait (not blood marker alleles) in soft gaited horses for those that fox trot and those that move more laterally or pace, are as different as the genetic differences that might be found in different breeds of horses. What a stretch that is! In fact it is not even a stretch, it is a total fabrication for the sole purpose of deceiving readers while attempting to make them believe there was a study done that supported something that it neither supported or even dealt with.

## 10. Private Research

The paragraph after the discussion of Cothran's findings in the V-factor discussion claims that in private research that horses that fell within a certain ratio of pace to trot consistently performed the same gaits or preferred to perform the same gaits. There are many pertinent questions to be asked about this so-called research that was supposedly done by the author of the V-factor discussion. Why wasn't the actual number of horses

involved stated? Was it a dozen, 50, 100, 250? The credibility of such a study would heavily depend on how many horses were involved. Why is there no description of how the experiment was performed, where it was done, were the horses video taped or reviewed in person? What protocol was used to assess gaits? Were the horses ridden, if so by whom, were they running free, who did the assessment and what was their training? How many people did it? What criteria were used in categorizing a horse's gait? Were the horses foals, yearlings, trained or untrained mature horses, were they on grass, dirt, in a ring, or ridden or led down a road. How long did it take to do the study? When was it done? Where the results of this study are is the major question. I have asked the author to show me the results but she never has. Anyone who carried out such an extensive and elaborate evaluation of gait would want to tell what they did, how they did it, and give details of what was found? Anything this noteworthy should have been published. Why is there no discussion of the pace-to-trot ratio that is referred to in this paragraph? Is the reader supposed to already know what it is? It just appears as "a certain ratio of pace to trot". We would never see a real scientist make reference to a "certain" ratio of anything. There is no introduction regarding what this ratio is, how it is computed, how it is inherited, how pace is determined, how trot is determined, how intermediate gaits are classified, or what, if any, genetic basis there may be for using such a ratio. Because there is no precedent to using ratios of traits in ancestors as a criterion in selecting breeding stock, it should be thoroughly explained and justified on a genetic basis including at least a hypothetical mode of inheritance and there should be data supporting the hypothesis that genetic ratio effects are heritable. Where is even a logical argument that such a ratio makes sense genetically? It is very strange that the claim is made that the ratios required to produce various gaits were determined in this study, yet not one ratio for one gait was given. Why wouldn't the author of such ground breaking and revolutionary research reveal the details of the findings and specify what the ratio range is for at least the running walk and the fox trot? Isn't that what this research was supposed to be about? Is it not important for the reader to know what those ratios are? Where are the data that back up the revolutionary and extraordinary claims? Are we to accept the word of someone who has obvious trouble interpreting and reporting published research done by actual geneticists even after the those researchers have clearly explained and summarized it? We have to question whether any such research was actually done at all. It makes no sense that someone claiming to have done so much work and who was able to acquire so much revolutionary information in equine gait genetics in a single study would then not give specifics about the study and its findings. Something is really fishy here. Before you believe any of what is claimed about the effects of ratios of traits in ancestors, try searching on the subject and see what you find. If you don't find anything, there is a good reason. It does not exist.

## **11. Pace/trot ratio**

The above seems to be the only discussion provided to validate the use of what goes on to be referred to as the "pace/trot ratio". Apparently what this refers to is the ratio of ancestors in a horse's pedigree that are categorized by the author as being trotters or pacers. It is subsequently claimed that it is this ratio of ancestors in a pedigree that ultimately determines gait in an offspring. There is a multitude of problems with this concept. One is that there are no known data to substantiate any form of ratio effect inheritance or the effects of a ratio of genes carried by ancestors on inheritance. Another is how would one know by looking at a pedigree whether an

ancestor gaited or not, let alone what gait it did if it did one? Plus there are unknown ancestors in many pedigrees and how do they and their get, get categorized? It appears that in the V-factor calculation unknowns are given a 0 score which means they are assumed to have been trotters or at least that they had no TWH blood in them. Yet another problem, which is as big as any of the other problems, is that the genes a foal inherits come directly from its parents and its parents only. A foal gets a random sample of one half of each of its parents' genes and a particular gene is either passed on or not passed on, i.e. they are not passed on in proportion to what their ancestors carried several generations back in a pedigree. Regardless of what the ratio in the ancestors may have been, the foal only has a chance at inheriting the genes that its parents carry. It is not the ratio of genes in the ancestors that matters. It is the genes that a foal's parents carry that determine what a foal may inherit. At a particular locus for a gene that affects gait each parent carries two alleles, let's say *A* or *a* to keep it simple. If they are heterozygous they may pass on either *A* or *a* and if they are homozygous they will always pass on either *A* or *a* depending on which one they are homozygous for. A foal will end up with either *A* or *a* from each parent and be either *AA*, *Aa*, or *aa*. That doesn't leave room for ratios other than 2:0, 1:1, and 0:2. What is not discussed in the claim about the importance of pace/trot ratios in ancestors is how such an effect could possibly be transmitted through genes and chromosomes to an offspring several generations down a pedigree. If one is going to argue that this is the key to gait inheritance, there must be an extended discussion of how many loci and alleles have to be involved for the ratios in ancestors to even be transmittable to offspring. If a plausible explanation for how this could happen were given, it may be an interesting idea to follow. It is amazing that this is being claimed as if it were something that is known in genetics when it is not, yet it is put forth with absolutely no data, no references that support it, and no genetic model to explain how it could possibly work. This idea seems to be the very foundation of the Foundation Foxtrotter Heritage Association. If so, the association has no more of a foundation than does the idea of inheriting ratios of genes, or the effects of gene ratios present in ancestors, does, and there is absolutely no foundation for that.

Think about this. There is no evidence at all that there is such a thing as heritable effects that originate from a ratio of genes or traits that appear to be present in the ancestors listed on an animal's pedigree. Combine that with the fact that the pedigrees that the trot/pace ancestor ratios are based on do not give any information regarding any ancestor horse's gait. Nonetheless, according to the V-factor webpage author, if we put these two things together with an arbitrary cut off V-factor value of 128 which is supposed to somehow be related to the ratio of pace to trot genes in a given horse, we then have the mechanism for maintaining foundation type Missouri Foxtrotting Horses in the Missouri Foxtrotting Horse breed and preserving the original Saddlebred and Morgan genes that still exist in the breed. Wow! What a fantasy.

## **12. Run away pace and “full pace progenitor”**

The assertion was made on the [2009 V-factor web page](#) that most gaited horse breeds are facing problems with runaway pace. Again, if it were so prevalent, why is any kind of documentation of the problem so scarce? Note that about here in the text the term "full pace progenitor" appears without defining what it is or why it matters. Is it a pacing horse way back in a pedigree somewhere? Can a horse 10 generations back have much impact on the gait of a horse? Their contribution would be  $1/2^{10}$  which is about 0.0010 or about 0.1% of the genes the horse would carry which is also about 1/1000th of the genes a foal inherits. Would it really matter if that distant ancestor was a trotter, pacer, or a zebra? Could this really be where run away pace comes from (assuming it comes at all)?

### **13. TWH - the source of pace evils**

The author toned down her attack on the TWH breed in the current version of the V-Factor document compared to the [2009 version](#) where it was claimed that it was the introduction of the TWH to the MFT breed in the '70's & '80's that has been the undoing of the foxtrot gait in the MFT breed and the TWH is what provided the opportunity for the pace to "quantitate" over generations. The MFTHBA books were closed in January, 1982, so not much could have been imported from TWHs in the '80's. The claim is made that a gaited TWH (I assume this may be one that fox trotted) carried more pace genes from a closer source than was present in the old Saddlehorses. The question here is how it is that a horse (a TWH) can carry more pace genes from a closer source (whatever that means because the TWH and MFT breeds come from very similar sources originally and unless a gene mutates it stays the same from one generation to the next so how close it is to a source has no effect on its strength) and those extra pace genes somehow do not affect the gait of the horse that is carrying them, it fox trots, but when those same genes are passed on to its offspring they make the offspring pace and then make the offspring's offspring pace, and so on, for all subsequent generations, and this apparently is the basis for pace "quantitating" in the MFT breed as the result of having TWH ancestors. This is either just a fairytale or it is new concept in genetics and worthy of an explanation as to how it happens genetically. Why are the effects of the pace genes expressed so differently in parent and offspring or from one breed to another? Many old time MFT carried genes from foundation horses like Allen-F1, Roan Allen, Merry Boy, Midnight Sun, Merry Go Boy, Midnight Mack K, and Walker's Merry Lad all of whom were registered TWHs. The old time MFT may have had more American Saddlebred (ASB) genes than TWH genes but Saddlebreds carried pace genes too. Were they somehow different? It seems reasonable to assume that a natural fox trot is the result of approximately the same configuration of gait genes regardless of the breed of the horse. One would have to have evidence that the combination of genes required for a fox trot in one breed is different than what is required in another breed before inferring what is claimed about the influence of TWH is true. Why and how would genes carried by the old time TWH's be so different than those in the same breed in the 1970's? Where would those different genes have come from? There is no evidence that pace genes in TWH's of the 1970's are more powerful than the existing genes in the MFT breed. The argument being made by the author of the V-factor is that the genes that allow a horse to gait are different among the three breeds ( ASB, MFT, TWH), with the TWH genes somehow being stronger because of where they came from originally but all gaited horses inherited their gaiting

ability from common ancestors that lived long before there were breed registries. Without evidence that there is a mutation in one or more genes that affect gait in the TWH breed, this assertion is indefensible and absurd. Both MFT's and TWH's have common ancestors from which they inherited the same gait genes plus the MFT breed carries genes from TWH breed that go back to the origins of the MFT breed and the early foundation horses as well.

The recently published research "Mutations in DMRT3 affect locomotion in horses and spinal circuit function in mice." in Nature ([Andersson, Lisa S., et al. \(2012\)](#)) reported the discovery of a mutant form of the DMRT3 gene that affects locomotion in both horses and mice. They found that a horse must have at least one DMRT3 mutant gene to be able to do a soft gait of any kind and must be homozygous for it to be able to do a soft gait and be able to pace. They found that all the gaited horse breeds carry the gene, including MFTs and TWHs. Their findings are based on sampling horses from many different breeds. These researchers made no reference to gait genes behaving differently in TWHs than any other gaited horse breed. They also made no mention of the ratio of the gaits of ancestors affecting a horse's gait. Their results are based on real data and the research was carried out by trained geneticists. Their conclusions are based on known genetic modes of inheritance and are straight forward interpretations of their data. They clearly differentiate the effects of the DMRT3 mutant gene being absent, heterozygous, or homozygous. Note that they explain what was done, how it was done, when it was done, where it was done, published their data, and then stated their conclusions. This is how scientific study results are always presented. Completely different than what we find on the V-factor webpage.

Another paper based on the same research ([Gaitedness of Horses Found Across the World, Vet Med and Biomedical Services, Texas A & M, Feb., 2014](#)) says this about the DMRT3 mutant gene: *"This recent research shows that the mutation arose only once and then spread across the world via positive selection, Andersson said. In other words, early humans probably noticed that some horses had the ability to move in unique ways, and they then selected those horses for breeding, most likely because they offered a smoother, more comfortable ride, called a "running walk" in some breeds. Horse breeds that are known to perform these "ambling gaits" are referred to as "gaited," and the researchers found that the mutated version of the gene is common in these breeds. They analyzed genes of 4396 horses from 141 breeds and found that the mutation is spread across Eurasia from Japan to the British Isles, in Iceland, in South and North America, and in breeds from South Africa."*

This conclusion confirms that the gene that allows horses to gait came long before the TWH, ASB, and MFT breeds existed and that it is the same gene from the same origin in all gaited breeds. So much for the "Full Pace Progenitor" existing in the TWH breed. The ability to pace came a long, long time before TWHs did.

## 14. Controlling the “quantitating” pace

Finally, a claim is made in the V-factor discussion that prior to breed registries when pace became too overwhelming, breeders would introduce trotting stock to rebalance the pace/trot ratio. It goes on to say that after breed registries were formed and the books were closed, breeders no longer had that option. It is claimed that the result of closed books was to make most gaited breeds become overwhelmed with pace. Most of the gaited breeds have little or no TWH in them although they do have common ancestry. The TWHs themselves are not all pacers by any means. How is it that according to the author of the V-factor other gaited breeds have pace "quantitating" without the influence of TWH blood, but it is the presence of too much TWH blood that is the main cause of the pace "quantitating" in MFTs? The FFHA isn't suggesting that the way to now control pace is crossing back to trotting stock as was done prior to gaited horse registries existing. They aren't saying it is highly advisable to not breed horses that pace or those that are too pacey. They say the way to control pace now is to go ahead and continue to cross gaited stock. Gaited stock in which it is claimed pace “quantitates” over time. Even more interesting and more contradictory, it suggests that crossing to gaited stock that are up to 50% TWH will control pace even though they have also claimed the TWH breed is a fountain of pace and has been the ruination of the fox trot gait in the MFT breed up to this point. These arguments are clearly inconsistent. If pace truly "quantitates" in gaited horse breeds, how can continuing to cross to gaited horses correct the problem of too much pace and/or prevent further "quantitating"? Why is it not necessary to cross back to trotting stock if pace is stronger than trot? What is it about limiting TWH blood in a pedigree that would stop the "quantitating" of pace that supposedly happens almost universally among all gaited horse breeds and has from the beginning of gaited horse registries, and occurs within the TWH breed itself where their genes are supposedly closer to a "full pace progenitor" and a source of more and stronger pace genes? This breeding plan is a collection of inconsistencies and really makes no sense at all.

In the V-factor discussion it is claimed that Saddlehorse and Morgan constituted 80% of the genetic makeup of the foundation horses in the MFT breed. FFHA states on their mission webpage that *their intent is to preserve the gene pool of old time Saddlehorses and Morgans that still exists in the MFT breed.* It would make a lot more sense to have minimum requirements for Saddlehorse and Morgan blood as a basis for eligibility in the FFHA than it does to have an arbitrary upper limit on TWH blood if preserving Saddlehorse and Morgan genes is truly their goal.

## 15. V-factor assumptions and calculation

Although it is never actually explained how a V-factor is determined in either the current or 2009 version of the V-factor webpage, the V-factor appears to be determined by counting, in some unspecified way, the number of times a horse's pedigree can be traced back to ancestors that were registered as TWH. It is stated that the pedigrees are traced to the 5<sup>th</sup> and 10<sup>th</sup> generation on the [FFHA bylaws webpage](#). No further details are available on the website, at least none that I could find. Given that it is the basis for eligibility, it should be clearly laid out as to what is involved in the process. The procedure appears to be completely ad hoc. One is apparently to assume that what is done is reliable, done without error, and that there is some genetic



justification as to why a V-factor value is a reliable estimate of the ratio of gait genes that an individual horse may or may not have inherited 5 or 10 generations down a pedigree.

According to the V-factor webpage a pure TWH has a V-score of 256 which is the maximum score. To be eligible for registration a horse has to have a score of 128 or less. Genes that come from any horse registered TWH are apparently considered to be from a pacer regardless of the gait the horse may have done itself. How much sense does it make to consider every TWH a pacer when most did not and do not pace? Why is the thing that matters most in a horse's pedigree the number of ancestors that were registered TWH? It makes no sense genetically to ignore the trait that is being selected for in a genetic selection program, i.e. gait. There cannot be effective genetic selection for the fox trot gait if the actual gait the ancestors did is completely ignored. Many TWH's were brought into the MFT breed as inspected fox trotting horses meaning it was certified by an expert, who reviewed them at gait, that the horses fox trotted. As we already pointed out, several of the MFT breed's foundation sires were registered TWHs. Again I ask, is it reasonable to assume that TWH's have different genetics for gait than do horses from other breeds that also display the fox trot gait? Should we not be more interested in the gaits the ancestors of our horses had than we are in how they were registered? If they fox trotted we can be confident their genetics were what we are looking for in foals we wish to produce today and know there is a chance at least some of those genes may have been handed down to our horses of today. What does knowing how ancestors were registered tell us about the gait genes they carried? There certainly is no evidence that all TWH carry the same genes for gait but that seems to be the way they are treated in V-factor calculations. Is there any better indication of the genes a horse carries for gait than the gait a horse does naturally? Pedigrees are of interest when breeding but never contribute nearly as much information about a horse as does the horse's own performance. If the V-factor is not related to gait, and there is no evidence that it is nor any genetic argument made as to why it should be, but is used as part of the criteria for selecting breeding stock, it will reduce the effectiveness of a breeding program by causing some horses with less gait quality to be included in the breeding program in place of a horse that has a superior gait but has a higher V-score. Breeders should concentrate on things they know are important. It is the gaits of the horses being bred together that are important when breeding for the fox trot gait, not their 5 or 10 generation pedigrees.

## **16. Testing the Validity of the V-factor**

My biggest disappointment in the V-factor and the FFHA is the lack of any testing of the validity of the V-factor before adopting it as the major underpinning of the organization. This is an unacceptable approach for implementing any new idea and certainly there was no justification for a registry being started based on someone's idea of something that may turn out to be a useful tool. It would have been straight forward to verify whether V-factor score is related to gait or not by simply surveying horses within the MFTHBA breed. It appears FFHA does not really want to know if there is a relationship. Think of the consequences if data were collected and analyzed but no relationship was found. The philosophy of the FFHA has been to use the V-factor as a tool in their breeding program without first any acquiring evidence that it is in fact related to gait or anything else. The logical way to proceed before adopting a new idea that is without genetically based merit, without any substantiating research evidence, and without a logical argument as to why it should work, would



be to establish its utility empirically by collecting data and looking for supporting evidence in the data. If the data support the idea that there is a relationship between gait and V-factor value, then there may be a basis for using it in a breeding program. A random sample of 40 or 50 horses would have been sufficient to establish if there is any relationship between a horse's preferred intermediate gait and its V-factor. A simple line plot or bar chart of the results would be informative. It is not reasonable to assume V-factor is somehow related to gait when there has not been one shred of evidence put forth that there is. In addition, choosing the value of 128 as the "magic" cutoff value that will establish the desired ratio of trot to pace to consistently produce fox trotting offspring is ludicrous. Given that it has never been established that there is a relationship between a V-factor value and gait, how could anyone possibly know the V-factor value that is appropriate for a fox trot gait without first establishing what the V-factor relationship with gait is? This is clearly not possible. The choice of 128 as a cutoff V-factor value was completely arbitrary and was used because there was no real basis for choosing a value. It was a "let's use the middle value" and hope for the best kind of decision, in my opinion, because the author had no idea what it should be and gave no supporting evidence as to why it should be 128. How could there be an idea? There were never any data, there was never any study, and never any evidence of any kind to go on. There still isn't, eight years after the registry was started. We don't even know what the preferred gait of a horse with a V-factor of 128 is. It could be a hard pace!

## **17. Breeding basics**

### ***1. Control pace by controlling gene frequency using selection***

It is well known that selection for or against a trait in a breeding population will change the frequency of the genes that affect the trait. Sound breeding practice for gait would be to select against too much pace in a population by excluding pacing horses and horses that tend to be pacey from the breeding population. If the goal of a breeding program is to produce fox trotting horses, the best approach is to cross horses that fox trot naturally until more information becomes available that might indicate some other approach may be more effective. We have no such evidence now.

### ***2. Uniformity of gait in offspring***

There is a statement on the V-factor webpage that breeds should be "standardizing" their gait but that is not what has been happening, mostly due to the "quantitating" of pace. My interpretation of this statement is that the author thinks it is possible to have a breeding program that will uniformly produce offspring that fox trot naturally, particularly if the horses being bred have the "right" pace/trot ratio. However, it is likely that a fox trot is the result of a configuration of several genes where some genes are in a heterozygous state at some of the loci that carry genes that affect gait. If that is the case, it is not possible to establish a breeding program that will consistently produce fox trotting offspring because of genetic segregation at reproduction. Consider a single locus in the heterozygous state,  $Aa$ . If two animals are bred that are each  $Aa$ , the offspring will be born in the following ratio: 0.25 $AA$ , 0.5 $Aa$ , and 0.25 $aa$ . If the fox trot occurs with the  $Aa$  genotype, 50% would be fox trotting horses. Of course the genetics of gait are likely more complex than this example, but the principle

remains that it is not possible to establish a breeding program that will consistently produce offspring that are heterozygous for any trait unless the homozygous states are both lethal in which case the only ones born live would be those that are heterozygous. Until much more is understood about gait inheritance, the surest way to produce horses with the traits you want, including gait, is to cross horses that have the traits you want the offspring to have. If a form of inheritance is well understood this may not be the case as in breeding for palominos for example. The surest way to produce palominos is to cross Sorrel/Chestnuts with Cremellos which produces 100% palominos. That is more effective than is crossing palominos with each other which results in only 50% palominos. However, before one can set up a more efficient breeding plan, one has to understand how the trait(s) of interest is(are) inherited and we do not know nearly enough of the details of gait inheritance to do something like that now. Think about this, how helpful would it be to know the ratio of sorrels to cremellos in a horse's pedigree back five generations if you were breeding for palominos? No help at all.

In the last sentence of the last paragraph of the V-factor discussion the author says: "*We can hope it is and that with this DNA study of the samplings we can identify the specific ratios of pace to trot needed to produce foxtrot into the distant future without the pace diluting it into extinction.*" This statement is made even though the author has up to this point in the discussion claimed to already have determined the required ratio of pace to trot through her own work (personal research as it was referred to). She has further claimed without any proof or evidence that a V-score less than 129 assures that the ratio of pace to trot will be in the range required so as to produce horses that consistently prefer the fox trot as their intermediate gait, referred to as the standardization of gait in the V-factor discussion. Given that the author claims to know what the required ratios are for various gaits, that the V-factor numerically quantifies the ratio, and that offspring having parents who's V-scores are less than 129 will inherit the required ratio of trot to pace genes, why does she need to hope for results to come soon from DNA studies? What purpose would they serve? I don't believe that ratios of ancestors' genes are something that can be determined through DNA analysis.

## **18. The FFHA Organization**

It is interesting to look at the FFHA organization itself. It appears to be run by the Managing Director. According to the FFHA [By-Laws](#) webpage, the Managing Director deposits the funds that are paid for membership dues, registrations, registration transfers, all gifts and donations, etc. It is specifically stated on the [By-Laws](#) webpage that the Managing Director will deposit funds, not the treasurer. The horses currently listed for sale on the FFHA's [For Sale](#) webpage belong the Managing Director. Although there are supposed to be 13 regional commissioners involved in running the organization and participating in monthly meetings, only one at-large commissioner is listed on the [Directors and Officers](#) webpage. There is no secretary or treasurer listed although the By-Laws state it is the treasurer's responsibility to do the accounting and post monthly reports. A search made on the [GuideStar](#) nonprofit organizations database did not find an entry for the FFHA. The business address given on the FFHA on the [Contact](#) webpage is a post office box number in Oxford, Arkansas with the same zip code as that of the Managing Director's post office box number in Oxford, Arkansas. It appears the organization doesn't meet its own obligations and responsibilities regarding its officers, directors,

regular meetings, financial statements, etc. It appears to be all but defunct. It is, however, apparently still able to deposit membership fees into an account controlled solely by the Managing Director.

## **19. Conclusions**

The desire to preserve old time breeding stock characteristics in Missouri Foxtrotters is laudable. Undue influence of show ring winners on breed characteristics is something that should be minimized. Many breed enthusiasts prefer to have horses that are smooth, agile and have athletic ability as their trail partners and have little desire for horses with the extreme reach and/or exaggerated over stride and head nod that are often rewarded in the upper level performance classes at the MFTHBA Celebration. Given that the FFHA is founded on the V-factor and that it has yet to be shown to be helpful in identifying horses that are foundation type horses or horses that naturally fox trot, it is clear that FFHA registration serves no purpose in maintaining the characteristics in the breed that many of us would like to see maintained. Choosing horses based on their conformation, disposition, and gaiting ability will do far more for perpetuating a foundation type of horse than choosing horses based on their V-factor value could ever do. In fact taking the V-score into account just gets in the way when making breeding or buying decisions. It only serves to take attention and emphasis away from things that really matter.

Until there is supporting evidence that shows unequivocally that horses with lower V-scores tend to pace less, there is absolutely no reason to care what a horse's V-factor value and there is no purpose served by FFHA registration. My main concern is that the V-factor is used as a marketing ploy that may make uninformed buyers pay more for a horse than they otherwise would pay because they have been misled to believe a V-score measures something related to the type of gait a horse may have or that it may affect its breeding potential. To date there is no evidence that is the case. The FFHA has had 8 years to acquire the needed evidence to show that their horses have less of a tendency to pace and are more often natural fox trotters than would be the case in a random sample of MFTHBA registered horses. They have made no move in that direction. I don't think they ever will. The safest thing they can do for their own preservation is to not collect data and they know it. They are afraid of the facts that would be revealed if data were collected and analyzed. They well should be.

People have told me that they wanted to know how much TWH is in their horse's pedigree and that's why they joined the FFHA. They were interested in knowing the V-factor score of their horse. My question to is what a V-factor score tells them that looking at their horse's pedigree wouldn't tell them. If there are several close up ancestors that are registered TWH, then their horse has a lot of TWH blood and if the pedigree shows TWHs far back in the pedigree but none up close, it only has a little TWH blood. No ad hoc calculations or FFHA membership fees required. What should matter to any owner is whether their horse's gaits are ones they prefer or ones they don't enjoy. If a person has a pacing horse with a V-Score of 16, they are no better off than someone who has a pacing horse with a V-score of 128 or more. It would be poor planning to breed a pacing

horse to a fox trotting horse in pursuit of an offspring that will be a natural born fox trotting horse, no matter what the pacing horse's V-factor may be, in my opinion.

## 20. References

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### Links to FFHA information

[FFHA Mission Statement](#)

[FFHA Bylaws webpage](#)

[FFHA Vfactoring webpage](#)