

Foundation Foxtrotter Heritage Association has a weak foundation

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Introduction

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 and use it as an 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 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 of the page to verify for themselves what the findings of the studies are. Withholding the specifics about any study casts doubt on the conclusions made by a

writer when their conclusions are supposedly based on the findings of a study referred to and this is done routinely in the V-Factor discussion given on the FFHA website.

Credentials

I would like to state my credentials before we begin. I have advanced degrees in statistical genetics from Michigan State University and I have done collaborative research with various researchers leading to about 90 [publications](#) in peer reviewed journals. I have taught analysis of variance, regression analysis, design of experiments, and statistical computing at the graduate level for 39 years. As a professional statistician for the past 40 years at Kansas State University, I have consulted with hundreds of graduate students and professors including many in the animal and biological sciences.

Presentation of findings and credibility

There are established protocols for presenting scientific results. Genetics is a biological science. Population genetics is not an area where laypersons can easily build the foundation on their own of the knowledge needed to enable them to understand and interpret results from research projects that are presented in the technical literature. When scientists draw conclusions from their own or other's research, they back up their conclusions by either citing specific references to the work of others or they present details of their own research along with data and analyses. This is done uniformly in science to ensure that an author writing from a certain point of view doesn't skew the interpretation of the results of others to favor whatever his point of view may be. The V-factor discussion is written as if it were a summary of scientific findings but it does not include the 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 presentation approach casts a shadow of doubt over the veracity, utility, or usefulness of the number FFHA calls a V-factor score because there is essentially no specific supporting evidence put forth.

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.

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 and that includes: [American Saddlehorse](#), [American Saddlebred](#), [Tennessee Walking Horse](#), and the [Missouri Foxtrotter](#), as well as some 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 included origins going back to Canadian Pacers, Narragansett Pacers, through the plantation horses, Thoroughbred, Standardbred, Morgan, and American Saddlebred. The Foxtrotter origins include 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 up until the books were closed in early 1982.

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. 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 an important problem as extensive as is claimed regarding run away pace in 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. The discussion goes on to say that pace had even affected 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

revealed. Second, what is the difference between a large majority and a substantial percentage and why wouldn't the actual percentages be 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? If it were a conclusion that the researchers drew from the results they found, they would not have "deduced" the meaning of their research. 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 is 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 we were to assume that trot is dominant to pace, or pace is recessive to trot, either of which would indicate that trot is stronger than pace contrary to the misinterpretation given by the author of the V-factor discussion.

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 18th 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 in 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 pacing performance: a mile in 2 minutes and 25 seconds. The books were closed in 1973.

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

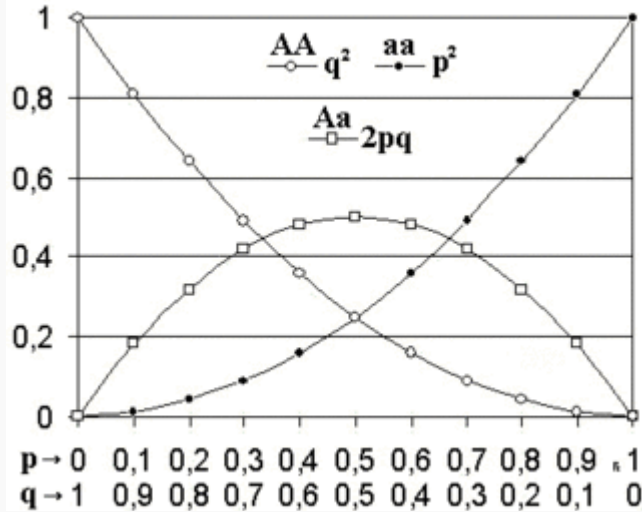
for many years, they have been bred much more as if they were two separate breeds most of that time. Their genetics reflect that they have not been interbred as are horses within all other breeds. It makes no sense genetically to generalize the results of the above study, or any other study done on Standardbreds, to trotters and pacers in general because no other horses that have different gaits but are in the same breed are kept anywhere nearly as separate as is the case in the Standardbreds.

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 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 what ever 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 given 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 generally somewhat faster, we have to be concerned that there may be a bias toward registering a horse as a pacer because it may be more saleable that way? 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 was not what determined how they were registered by their owners.

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 offspring and the frequency of the genes that determine the genotypes for the traits in 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 nearly 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 gene 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 genes for the traits that exist in the breeding populations than they are by the relative strength 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 relatively 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. 3/4th trotters and 1/4th 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 value such as 0.6 or 0.7 we might more nearly duplicate the results cited in the V-factor discussion. The point, a very important point, 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 similar results to this example could be used to deduce that pace is stronger than trot. No one really knows. It is not possible to conclude anything about relative strength of trot and pace when we know so little about how gait is inherited. To my knowledge no geneticist has claimed to know ([Gaited Horse](#)). There is an interesting discussion of gait called "[The Essence of Gait](#)" that I think is worth reading and will convince anyone that there is more to it than simply trot versus pace. Although no one knows what the relative strengths of the traits that effect gait are, there is some evidence that ability to "gait" may be largely a recessive trait because it shows up when two horses that are not gaited are bred together. One well known example is in the Morgan breed. Although not originally a trait that was included in the breed standard, there are continually horses produced that 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, if anything it shows that gaiting ability is a recessive trait which is often hidden by the presence of dominant genes that encourage a horse to trot or discourage it from gaiting, however you want to look at it.

Misinterpretations of published research

Study details

Subsequent to the claim that "we know pace is stronger than trot", which we do not, the author makes reference to research done by Dr. Cothran using Standardbreds. Although the paper itself is not cited, I was able to find the published results of the research and they are very different than what the author the V-factor reports from them. The publication is: "*Genetic Differentiation Associated with Gait Within American Standardbred Horses*" (Cothran, et al. 1987). Note I

have emphasized the last 4 words in the title as they are extremely important regarding the application of the findings of this research and they were totally ignored and left out of the discussion presented about the results of 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 above as well. Again I point out that these are unreliable estimates of the proportions of actual gaits the horses displayed because registration does not require gait verification.

On page 286, 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 Standardbreds only and they clearly state that they didn't do any analysis regarding gait, they were interested only in the 23 marker loci which are not 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.

Conclusions of the researchers

This research 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 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 in their genetic makeup. The genes that were studied were alleles at 23 loci that effect cell and blood serum proteins and enzymes. That included no genes that were known to be associated with gait. Horses that commonly interbreed as is the case in almost all other horse breeds, have similar frequencies among the horses within the breed for these blood marker alleles because there is no selection for or against them. These genes are dispersed throughout a breed at random as a result of being unknown and of no interest to breeders and they establish a pattern of frequencies that are unique to a breed due to what is called random drift. 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 samples of horses within a

breed. This is not surprising given the unique history of the breed and the different origins of the trotters and pacers within it. The question of interest is whether the differences that still remain between the two groups are due to their different origins or due to the fact they have different gaits, or perhaps some of each. The authors do not claim to know the answer to the question. 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.*"

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 the study. It showed no such thing. Molecules were never mentioned. All it showed is that the pacers and trotters within the Standardbred breed had different gene frequencies for some marker alleles and the authors stated they did not know if this was due to the history of the breed but they clearly said it may be. Of course some differences in the frequencies of some of the marker alleles could be related to gait genes if they happen to be located close to a gait gene on the chromosome that they reside on. The author of the V-factor discussion failed to mention that the study was done with Standardbred horses which puts a very different light on the interpretation of the results. To say that the differences that were found in the frequencies of the marker alleles between the trotters and pacers within this breed is the first time science could differentiate between the gaits at the molecular level is to me an unbelievably misleading conclusion to make. The author of the V-factor page concludes the 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 author purposely makes it sound like this study established that trotters and pacers are as different as two different breeds, period. No qualifications. The fact that this study was done within the Standardbred breed and applies only to it because its history is so unique is not mentioned. The authors of the research clearly pointed this fact out for the reader. This is not something that could have been missed. Ask yourself if the author of the V-factor discussion has the ability, or intention, to correctly summarize other studies that are alluded to. This author was either unable or unwilling to interpret this study correctly even when the authors stated clearly what they did, what the results were, and drew appropriate conclusions themselves? Again we ask why wasn't the reference to this research given in order to allow a reader to read it and draw their own conclusions. That is what is always done with references to scientific findings

about genetics or anything else. It is done to prevent exactly what was done here. To prevent results from being skewed such that they are used to make it seem like they support something that they do not support.

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 several pertinent questions of interest. Why wasn't the actual number of horses involved stated? Why is there no description of how the experiment was performed, what protocol was used in assessing gait, were horses ridden, running free, who did the assessment, what criteria were used in categorizing a horse's gait, were these foals, yearlings, trained or untrained mature horses, were they on grass, dirt, in a ring, or ridden down a road, how long did it take to do the study, etc.? Does it not seem that anyone who carried out such an extensive evaluation of gait would want to tell what they did and how they did it? I would think they would want to publish the results. We also must ask why there is no discussion of what the ratio referred to in this paragraph is. It just appears as "a certain ratio of pace to trot". There is no introduction as to what this ratio is, how it is computed, how pace is determined, how trot is determined, how intermediate gaits are classified, or what genetic basis there may be for the use of such a ratio. If there is a precedent for its use, it should be clearly documented. I don't recall having ever seen anything about ratios in ancestors being used to select breeding stock in a breeding experiment. If there is no precedent, its use should be thoroughly discussed and justified on a genetic basis including at least a hypothetical mode of inheritance. Where are the references that establish that whatever this ratio is makes sense genetically? Where is the logical argument that such a ratio makes sense genetically? The claim is made that the ratios required to produce various gaits were determined but not one ratio was given. Why wouldn't the author of such ground breaking research reveal the findings and specify what the ratio range is for at least the running walk and the fox trot? Isn't that what this was all about? Isn't it important for the reader to know how different they are? Where are the data for the extraordinary claims made in this paragraph? Are we to simply accept the word of someone who has serious trouble interpreting published research done by geneticists? Was this research that was actually done with horses as it is made to sound like it was, or is it based solely on horse pedigrees where the gaits that the horses did were simply filled in by the author as either trot or pace depending on her opinion of what it should have been based on a horse's pedigree? It appears to have been the latter and that means there was never any real research done.

Pace/trot ratio

The above seems to be the only discussion provided in order 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 such claim. Another is how would you 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 had no TWH blood in them. Yet another problem, which is as big as any, 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 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 be, the foal only has a chance at inheriting the genes that its parents inherited. It is not the ratio of genes in the ancestors that matters. It is the genes in the foal's parents DNA that come into play. At a particular locus for a gene that affects gait each parent has 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 1:0, 1:1, and 0:1. What is not discussed in the claim about the importance of pace/trot ratios in ancestors is how the effect could be transmitted through genes to an offspring. There must be a discussion of how many loci and alleles have to be involved for the ratios found in the ancestors to even be transmittable to offspring, if one is going to argue that this is the key to gait inheritance. 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 something that is known in gait genetics and being put forth as such with absolutely no data, no references that support it, and no genetic model to explain how it could work. This idea seems to be the foundation of the Foundation Foxtrotter Heritage Association. If so, a foundation is pretty well absent.

Run away pace and “full pace progenitor”

The assertion is made on the V-factor web page that most gaited horse breeds are facing problems with run away pace. Again, if it is so prevalent, why is any kind of documentation of the problem so hard to find? 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, way back in a pedigree somewhere? Can a horse 10 generations back have much impact on the gait of an offspring? Their contribution to a foal would be $1/2^{10}$ which is about 0.0010 or about .1% of the genes the foal 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 be where run away pace comes from (assuming it does come)?

TWH - the source of pace evils

The author goes on to claim 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 it is what provides the opportunity for the pace to "quantitate" over generations. The books were closed in January, 1982, so not much could have been imported in the '80's. The claim is made that a gaited TWH (I assume this means 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 affect on its strength) and those extra pace genes somehow do not affect the gait of the horse that is carrying them, he fox trots, but when those same genes are passed on to his offspring they make the offspring pace and make their 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 a 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 the other? The old time MFT had more American Saddlebred (ASB) genes than TWH genes but those horses 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 before inferring this to be the case. There should also be evidence that pace genes in TWH are more powerful than the existing pace genes in the MFT breed. Without evidence that these things are true, there is no basis for assuming they are. It appears that the argument being implicitly made may be that the genes that make a horse gait are different among the three sources with the TWH genes somehow being stronger because of where they come from. Again, without evidence that there is a mutation in one or more of the genes that affect gait in the TWH breed, this assertion is indefensible. Both breeds have common ancestors from which they inherited gait genes plus the MFT breed carries genes from TWH breed that go back to the origin of the MFT breed. There are no data that show the genes carried by the breeds are somehow different or have different potency in their effects or that TWH's carry more pace genes. To make such a claim requires proof if one is to be taken seriously. No proof is given.

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 balance 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 may have common ancestry. The TWH's 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 MFT's? The FFHA isn't suggesting that the way to control pace is crossing to trotting stock as was done prior to registries. They don't seem to be saying it is highly advisable to not breed horses that pace or those that are too pacey. They say the way to control pace is to go ahead and continue to cross gaited stock. Gaited stock in which it was 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. These arguments are 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 gaited horses and has from the beginning of time 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 filled with inconsistencies.

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 exists in the MFT breed. It seems like it would make 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 upper limit on TWH blood if preserving Saddlehorse and Morgan genes is their goal.

V-factor assumptions and calculation

Although it is never stated how a V-factor is determined on the webpage, the V-factor appears to be determined by counting, in some unspecified way, the number of times a horse's pedigree goes back to an ancestor that was registered TWH. It is stated that the pedigrees are traced to the 5th

and 10th generation on their 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 score is a valid estimate of the ratio of gait genes that an individual may or may not have inherited 5 or 10 generations down a pedigree.

According to the V-factor webpage a 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 considered to be from a pacer regardless of the gait the horse itself did. 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 can not be effective genetic selection for the fox trot gait if the actual gait the ancestors did is 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. 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 gait genes but that is 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 slow the progress and 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. The gaits of horses being bred together are what is important.

Testing the utility of the V-factor

The biggest disappointment concerning the V-factor and the FFHA is the lack of any testing of the utility of the V-factor before adopting it as the major underpinning of their organization. This

is an unacceptable approach for implementing any new idea. It would have been relatively straight forward to verify whether V-factor score is related to gait or not by simply surveying horses within the breed. It appears FFHA may not really want to know. The philosophy of the FFHA has been to use the V-factor as a tool in their breeding programs without first acquiring evidence that it is in fact related to gait. The logical way to proceed before adopting the use of an 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 evidence in those data. If the data support the idea that there is a relationship, then there may be a basis for using it in a breeding program. A random sample of 40 or 50 horses would be sufficient to establish if there is any relationship between a horse's preferred intermediate gait and its V-score. A simple plot of the results would be informative. It is not reasonable to assume V-score is somehow related to gait when there has not been a shred of evidence put forth that there is. In addition, choosing the value of 128 as the "magic" value that will establish the desired ratio of trot to pace to consistently produce fox trotting offspring is ludicrous. It has never been established that there is even a relationship between V-score and gait. How could anyone possibly know the V-score 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.

Breeding basics

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 two horses that fox trot naturally.

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, 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 genes where

some genes are in a heterozygous state at some of the loci 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 much 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 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 them is to cross sorrels with cremellos which produces 100% palominos. That is more effective than is crossing palominos with each other which results in 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.

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 it was referred to as). She has further claimed, without any proof or evidence of any kind, that a V-score less than 129 assures that the ratio of pace to trot will be in the right range so as to produce horses that consistently prefer the fox trot as their intermediate gait, referred to as standardized for gait in the V-factor discussion. Given that the author claims to know what the required ratios are for various gaits and that the V-factor assures those ratios will be inherited in the range required for the fox trot gait by offspring having V-scores less than 129, why does she hope for results to come soon from DNA studies? What purpose would they serve?

References

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Lasley, J. F. (1978) *Genetics of Livestock Improvement*. Prentice Hall, Englewood Cliffs, New Jersey.

Links to FFHA information

[FFHA Mission Statement](#)

[FFHA V-factor webpage](#)

[FFHA Bylaws webpage](#)