ABSTRACT ON THE INHERITANCE OF GAIT IN EQUINES

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1)EQUINE GAIT INHERITANCE

During the development of a new breed of horse where middle gaits and Lp gene spotted coats were desired, the hypothesis that there is a gene for gait, was also tested and verified, but not mapped.

The work was done by myself, and observed and verified by my husband T.Mark Varley and Dr. S.McCall our farm veterinarian for the past 15 years, with over 100 horses observed and blood typed. While various breeds were used to extract the desirable components for the new breed, if qualified, most of their offspring were registered as Tiger Horses with TIGRE, a Registry I created to promote and protect the emerging breed. This new "Tiger Horse" breed should eventually share the phenotype of an extinct one that is said to have been used to hunt the Siberian tiger.

In order to create a colorful and gaited breed that would share an Iberian profile, (horses with Iberian profiles were developed by the Spanish several centuries ago. Some including those with spots and gait were in shipments to the USA during the 1800's*).* I located individuals that shared this pheno-type from a variety of unrelated breeds. These were homozygous Appaloosas but that did not necessarily gait, and non Appaloosas that did gait. I chose as many breeding prospects as possible that shared certain desirable physical traits, regardless of gait or color. I found some individuals that were already first generation out-crossed, ie., Appaloosa X TWH or Appaloosa X MFT etc. For further discovery I also used one (diagonal) non-gaited Arabian line as well as one non-gaited (lateral) hard pacing line.

Gaited horses should perform one or more of the three most commonly recognized middle gaits. Although gaited horses can also trot and sometimes perform a hard lateral gait, they must never exclusively perform a hard trot or hard lateral pace, which are outside the realm of middle gaits.

The on-going work was done over a period of 18 years beginning in 1992, by cross-breeding gaited horses to non-gaited horses. We are currently recording 3rd and 4th generation offspring, and have begun selecting from these where both parents gait, and/or demonstrate copies of the Lp gene. Several have inherited the desirable oriental angled eyes, and a refined Iberian profile with a slightly convex nasal bone, large well placed eyes, and triangular shaped heads.

A total of 41 mares and 15 stallions (parent horses and offspring) are recorded here, consistently exhibiting verifiable evidence that there is a gene for Gait, and that Gait is gender related. The only exception involves a specific type of LP/LP (homozygous) horse, for which there is a separate study underway.)

Gaits described:

"Gaited horses" are commonly known for performing the following middle gaits:

a) Running Walk. Referred to as an evenly timed square gait, where each foot moves independently of the others, in what is described as an "evenly timed 4-beat rhythm," ie, 1,2,3,4 repeated by 1,2,3,4

b) Stepping Pace. Referred to as, "an unevenly timed lateral gait." Ie,1,2 & 3,4 &

c) Fox Trot. Referred to as, "an unevenly timed diagonal gait." Ie 1,2 & 3,4 &

There is a newly discovered middle gait we have named;

d) Shuffle. Also referred to as, "an unevenly timed lateral or, diagonal gait," this is the least comfortable to ride and tends towards the hard trot.

Some gaited horses are capable of performing more than one of the above "middle" gaits. Gaited horses are described as always having at least one foot on the ground therefore eliminating any bounce to their forward movement. They sort of "crawl" like a spider might, but at speeds ranging from 13-27mph. Often referred to as an arm-chair ride, no special rider skill is required to sit most gaited horses.

As a comparison, it is necessary to recognize and describe horses that are outside the realm of "middle gait." There are two types of "non-gaited" horses, both exhibit an evenly timed 2-beat rhythm.

a) The Trot. Referred to as an evenly timed diagonal gait, opposite pairs of legs lift together, move forwards together, and strike the ground simultaneously, followed by the opposite pair in a perfect 2-beat rhythm. The Trot causes the horse to bounce in order to transition from one diagonal pair to the other. It is a stable and efficient gait, but requires rider skill to enjoy.

b) The Pace. Referred to as an evenly timed lateral gait, where same side pairs of legs lift together, move forwards together, then strike the ground simultaneously then followed by the opposite same side pair creating a perfect 2-

beat sound or rhythm. The Pace causes the horse to roll from side to side in order to move forwards. It is an unstable but extremely fast gait, best suited to other than rider use.

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CONCLUSION:
When one parent is gaited and one parent is not gaited, parent gait is inherited by the opposite sex foal. ie, daughters inherit gait type from their sires, while sons inherit gait type from their dams. The inherited "middle" gaits are usually, but not always identical to that of the opposite sex parent. Example: Lateral middle gaiters bred to diagonal middle gaiters have sometimes produced foals that tend to be more evenly timed in their way of gaiting, than that of either gaited parent. Foals born from Hard Pace X Hard Trot horses, are either Hard Pacers or Hard Trotters having inherited their gaits from the opposite sex parent, and with no obvious variations in strength or rhythm. This confirms that there is a gene for gait and that depending on the sex of the foal, gait inheritance is predictable.

2) INTRODUCTION:
During the creation of a new breed, ie, a spotted/gaited horse, and one that is intended to share the pheno-type of an extinct breed from China/Siberia, gait inheritance was observed to be gender related, ie, sons inherit the gait of their Dams, and daughters inherit the gait of their Sires.

"Gaited" is a generic term for horses that can perform a 4th, or "middle gait," other than the usual walk, trot and canter gaits, but does not exclude those gaits. Gaited horses provide a comfortable ride as there is no bounce or roll during rhythmical stride changes. Many pre-historic animals such as the Giraffe, Hyena, Elephant, Cheetah, and a variety of Antelope and the single hump camel, perform similar gaits to those of the laterally gaited horse. Many modern day dog breeds perform a middle gait especially observed in hunting types and the German shepherd breed. Often lateral in nature, these strange looking gaits are energy saving, and appear necessary for animals that must travel great distances between grazing or hunting plains, and watering holes.

Since no horses could be found that met all of the above criteria, work primarily focused on gathering individuals that 1) might transfer middle gaits or 2) might transfer copies of the leopard complex gene. Individuals in both cases were often selected for their pheno-typical resemblance to one another and to the Soulon horses depicted in ancient Chinese art during the T'Ang Dynasty 615-780 and which shared what is today referred to as an Iberian profile.

Being forced to use individuals that gaited with those that did not gait, I was able to identify in the first generation that parents gaits were inherited by the opposite sex foal. Progeny that were both spotted and "gaited," were then selected as future breeding stock. Progeny that were gaited but not spotted, or spotted but not gaited, but which bore the desirable pheno-type for the new breed were also included in the "keeper" mix and then bred back to suitable opposite type partners. This latter group continued to verify that gait is gender related.

During the recorded use or production of over 100 assorted individuals, I learned that all types of horse inherit gaits that are lateral, square or diagonal. The "square" (running walk) middle gaiters are the most comfortable to pleasure ride, holding steady in an evenly timed rhythmical stride. The less perfect diagonal Gaiters will occasionally break to the hard Trot, while the less perfect lateral Gaiters will occasionally break to the hard Pace. My work continues in the development of a Breed where it will readily be identified as one that routinely performs the perfectly square "Running Walk. While large numbers should display the exotic coat patterns of the Appaloosa, non spotted coats will also be in the mix and help to promote good facial and genital pigmentation, for sun protection. Regardless of color, all will "gait," share an Iberian profile with oriental slanted eyes and be of athletic body and kind disposition.

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3) MATERIALS AND METHODS:

A)

Materials used: A total of 41 related, and un-related mares, and 15 related and un-related stallions, including some offspring are involved in production data.

Method used: Breeding together unrelated and related pairs with opposing and/or similar gaits of all known types.

Experiment #1 involved *(Machines Pure Pride*) a stallion who performed what is known as the hard Pace. The hard Pace is a lateral gait commonly identified in the Standard-bred Breed, where same side legs, (lateral pairs) work in unison to propel the horse forwards. This unstable gait forces the horse to roll from side to side in order to lift and follow through with the opposite pair. This type rarely if ever will be capable of the diagonal hard Trot and is the exact opposite of the hard Trot. There is an evenly timed 2-beat rhythm to the hard Pace where lateral pairs strike the ground at precisely the same time.

Mares used with the hard Pace stallion performed either the hard Trot gait, or one of the kinder middle gaits and delivered foals of both sexes. Data for identifying gait inheritance was probably more easily gathered using opposite types, than it might have been using horses of the same type where differences in gait strength, would be barely discernible.

This stallion produced a total of 12 foals. 7 were stud colts and inherited their Dam's gait. Three foals from 3 unrelated trotting type mares were fillies, and inherited the undesirable hard Pace of the sire. This ended experiments using a hard Pace stallion.

(The following tables show mares used, stallions used and their resulting foals.
INSERT STATISTICS)

IDENTIFYING GAIT INHERITANCE IN THE NEWBORN FOAL**.**

Trotting breeds produce trotting foals. hard Pace breeds produce hard Pace foals. That is an established fact, but when a Gaited parent is bred to a non-Gaited parent, or when the gaited parents vary in type, ie, diagonal to lateral, closer scrutiny is necessary to identify the specific inherited gait of the foal. In the new born foal, specifics of inherited gait is not always accurately diagnosed, as the gait will vary from month to month and as the foal goes through growing stages. A foal will elevate slightly in the rear and then a few weeks later the front end will catch up, only to see the back end elevating once again. This "sea-saw" motion continues until the foal is fully mature. Therefore any foal whose gait is not honest will demonstrate a variety of middle gaits until fully mature. The specifics of inherited gait then are more easily recognized in adults after the variations have settled down, and the horse exhibits a middle gait preference, on a consistent basis. Foals are easily mis-diagnosed, especially when exhibiting the Running Walk, which most types seem to do in the first days of life. This is also true of non-gaited horses, especially trotters. Identification of any gait using the naked eye should be left to the Experts. Video inspection for all others is the best tool for accurate diagnoses as it allows one to advance the horse's cadence frame by frame. Observing leg and hoof co-ordinates using video will give us the most accurate information. Unless a foal is obviously lateral in its gait when born, it is best to wait until it is 6 months of age or older, to identify gait. Honest inherited gait will be quite apparent by that age.

IDENTIFYING GAIT INHERITANCE IN THE MATURE HORSE.

A gaited horse will perform gait either laterally, diagonally or squarely. To identify whether a mature horse is laterally gaited, we must concentrate on same side pairs of legs. Lateral gaiters will lift same side legs together, or almost simultaneously, and move them forwards together, or almost simultaneously, but then the hind will strike the ground first, followed by the same side fore. The opposite lateral pair then follow suit creating an imperfect 4-beat rhythm.

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The more uneven the timing is of the lateral gaiter, the more tendencies there are for the horse to break to the non-gaited gait of the hard Pace. The laterally gaited horse can vary between almost perfect middle Gait to a hard Pace. No matter how close lateral gait is to square, if it is not perfectly square, the 4-beat rhythm will be interrupted to create an imperfect 4-beat rhythm. This type has been clocked at speeds of up to 30mph especially when gait is closer to the hard Pace. Horses that show a preference for extreme lateral gait will sometimes break to the hard Pace and are referred to as “Pacey Horses” which should not be confused with “a hard pace horse.”

To identify whether a mature horse is diagonally gaited, we must concentrate on opposite pairs of legs. Ie, left hind and right fore and then right hind and left fore. As the diagonal pairs work almost simultaneously together, the exact opposite of the lateral gait will take place. Here the fore will strike the ground ahead of the opposite hind, creating an imperfect 4-beat rhythm. The more evenly timed the rhythm to 4 beats, ie 1,2,3,4 1,2,3,4, the closer the gait is to square and therefore “perfect.” The more uneven the timing ie, 1&2&, 1,2, 1&2&, 1,2, the closer it is to the evenly timed 2-beat gait of the trotting horse ie 1,2 1,2 1,2 Horses that are too close to the hard Trot in rhythm, will occasionally break to the Hard Trot. We refer to this type of gaited horse as “Trotty” but should not be confused with “a hard trotting horse.” This type can stay in gait at speeds of 6-8mp and routinely clocked at 13mph. In both diagonal and lateral cases riders need to pay special attention to keeping Trotty or Pacey horses, in middle gait.

To identify whether a mature horse is square gaited, we must concentrate on individual legs. The square gaited or “Running Walk” Horse, is the easiest to identify as it mimics the working walk with an evenly timed 4-beat rhythm. Each foot works independently of the other 3. The Running Walk horse moves into various speeds beginning with the 4mph working walk, to the “running walk” reaching speeds from 8-13mph. When asked for faster than that, this type has been clocked at from 13-27mph never missing a beat and remaining in the evenly timed 4-beat gait we then identify as “The Rack.”

In the lateral or diagonally gaited horse there will always be a discernible delay between a working pair striking the ground. An evenly timed 1, 2, sound is not that of the gaited horse, but that of a hard Trotter, or a hard Pacer. These two are what we call “outside the realm of middle gait.” Most horses on superficial inspection, whether gaited or not, appear able to perform the 4-beat rhythm of the common walk.

To get really technical, all types of horse will perform a variety of efficient ground covering speeds. Depending on the region involved in the USA, each speed has a different name. As the horse changes speed, not “gait,” changes will necessarily take place in the horse’s “collection.” A trotting horse will go from the walk to a collected working trot, to an extended trot. A laterally gaited horse will go from a walk to a lifted stepping pace, to a flying pace, and a diagonally gaited horse will go from a Fox Walk, to a tightly collected Fox Trot. The square gaited horse will go from a walk, to a loosely collected running walk, to a tight frame collected rack. Hard Pacing horses go from a hard lateral walk to a hard lateral pace, neither of which are collected.

For the purpose of this submission, I have addressed all the commonly known and accepted gaits, but there is one little known middle gait that initially was only possible to identify using a video camera. It is known as the Shuffle or Gliding Ride. It closely resembles the hard Trot in that diagonal pairs work together. In some cases this “Glide” gait is identified as a lateral gait and in others it is identified as a diagonal gait. A horse will perform one or the other depending on its disposition. What makes one lateral and the other diagonal is the placement of the fore. The lateral Glider and the diagonal Glider both lift diagonal pairs almost simultaneously, move them forwards almost simultaneously, but then place them differently from one another. In the lateral horse, the hind will strike the ground, followed very closely by the opposite fore which during transition drops “ahead of the vertical,” (the vertical being the already placed and upright fore). In the diagonal horse, the fore will transition behind the vertical. There is hardly any bounce to the Glide which enables the rider to sit this “broken trot” quite comfortably. More study on the inheritance of the Glider gait is required as it appears that most horses of either group, can and do “shuffle/glide.”

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CONCLUSION.

All but hard pacing horses will adjust their gait for a safer traverse on undulating terrain. True inherited gait is only evident when horses are traveling on a level playing field with good traction. Shoes or no shoes, a horse's gait should never vary in honesty. Only the Glider will refuse to "glide/shuffle," if the terrain is hard and slick, as in order to perform the glide, the hind must slide into place followed closely by the opposite fore which drops into place. Slick surfaces would be dangerous for the slide of a Glider. Of course size of enclosure will interfere with the regular gait of a horse, as will a steep or rolling terrain.