THOROUGHBRED TIMES
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BLOODSTOCK TOPICS

Scientist links mtDNA, racing ability

Mitochondrial DNA may be related to stamina and precocity, according to recent study

by Pete Denk

A BRITISH scientist studying mitochondrial DNA (mtDNA) believes he has made a historic breakthrough that could unlock secrets racehorse breeders have wondered about for 300 years.

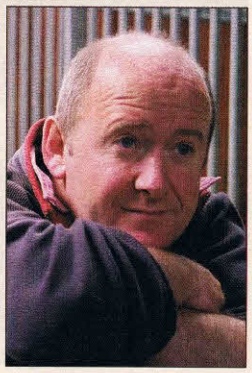
What makes one horse peak as a two-year-old while others get better with age? Why do the distance preferences of sire and dam sometimes conflict with their progeny? What is the best way to balance speed and stamina in a pedigree?

Stephen Paul Harrison, Ph.D., believes part of the answers to those questions is in mtDNA, genetic material inherited solely from the female side that is passed down through a female family with little mutation from generation to generation.

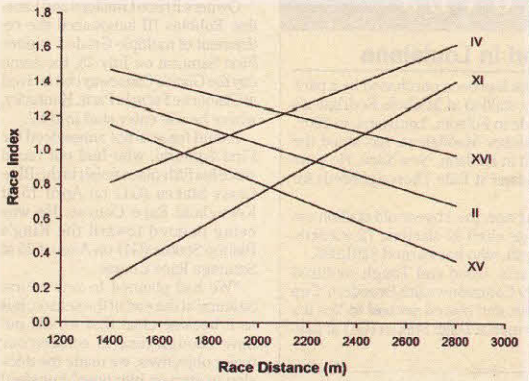
MtDNA carries encoding for respiratory chain enzymes and is believed to demonstrate one of the clearest associations between genetics and athletic performance in both humans and horses.

Harrison's company—Kent, England-based Thoroughbred Genetics—has completed a six-year study of mtDNA that was published in April in the scientific journal *Mitochondrion*. Harrison and his team, which includes Juan Luis Turrion-Gomez, discovered what they have termed significant associations between a horse's mtDNA and racetrack performance, specifically in its correlation with optimum racing distance and peak racing age.

"We think mtDNA analysis is useful because it shows an association between genes and performance in racehorses, and up to this point, nobody's been able to say that before," Harrison said.



ESTABLISHED LINK
Dr. Stephen Paul Harrison and his Thoroughbred Genetics company in Kent, England, uses mitochondrial DNA analysis to predict racetrack performance



RACES USED FOR THE STUDY:
Fred Darling Stakes, Greenham Stakes, Nell Gwyn Stakes, and Jersey Stakes at about 1,400 meters; One Thousand Guineas, Two Thousand Guineas, St. James's Palace Stakes, Coronation Stakes, and Craven Stakes at about 1,600 meters; Sandown Classic Trial Stakes, Musidora Stakes, and Dante Stakes at about 2,000 or 2,100 meters; Lingfield Derby Trial Stakes, Epsom Derby, Epsom Oaks, Ribblesdale Stakes, King Edward VII Stakes, Great Voltigeur Stakes, Chester Vase Stakes, and Gordon Stakes at about 2,300 meters or 2,400 meters, and the St. Leger Stakes at about 2,800 meters

Unlocking the secrets

It would be a fascinating breakthrough if mtDNA alone could predict a horse's best distance or explain the phenomena of the brilliant, promising two-year-old that fails to train on at three.

While the study found significant correlations between mtDNA and running aptitude, it could not take into account the many other inherited materials that could affect performance, not to mention training methods. Those necessary omissions could be seen as a shortcoming, or they could be seen as a testament to the importance of mtDNA, considering the correlations the study suggests.

"Wherever we drew conclusions, we were happy with the data, because they were so obvious," Harrison said. "The data is what it is. We couldn't be surprised or not be surprised. There was a chance mtDNA did have an effect on performance and a chance it didn't. Our study shows it does."

The study initially used mtDNA samples from 1,000 horses that raced in England between 1953 and 2003. Their bloodlines represented 33 distinct female lines. Those 33 female lines account for 98.9% of the current horse population in England, according to *General Stud Book* records.

Although not germane to the focus of the study, Harrison discovered that the mtDNA found in 19 of those 33 female families was not what it should have been, indicating a significant number of mistakes somewhere in the recorded pedigree lines. Those discrepancies are similar to those found in earlier mtDNA studies.

"All horses derived from the same female line should have the same mtDNA, which wasn't always the case," Harrison said. "It's easy for that to happen if you got a whole lot of foals and mares in a field. I don't think the stud book is full of skullduggery. Most of the time it's probably due to an honest mistake."

Using *Raceform* records to identify the winners of 21 major English three-year-old races between 1953 and 2003, Harrison's team assigned those horses an mtDNA haplotype (a set of closely linked alleles—genes or DNA polymorphisms—inherited as a unit) based on their breeding and the patterns observed from the initial 1,000-horse sample. Each horse was placed into one of 17 genetic haplotypes based on the combined variation of mtDNA.

Harrison then calculated a racing index for each mtDNA haplotype by dividing its percentage of wins in the major races with that haplotype's occurrence in the horse population. Harrison used the results of those 21 races, ranging in distance from about 1,400 meters (6.96 furlongs) to 2,800 meters (13.92 furlongs) (the races were run in furlongs), to use as a stamina performance indicator.

As shown in the accompanying graphic, several patterns emerged. Two of the haplotypes showed clear improvement as distance increased, while three other groups won more than their fair share of sprint races but gradually decreased in effectiveness in longer races.

Horses with what Harrison assigned as Type IV mtDNA—he declined to reveal the actual female families—had a racing index of 0.84 in races between 1,400 meters and 1,600 meters (7.95 furlongs). But that haplotype's RI was 1.41 at 2,000 meters (9.94 furlongs) and 1.34 at 2,400 (11.93 furlongs) meters. Haplotype XI was even more dramatic, with a paltry 0.21 RI in the sprint races but an increase to 1.06 at 2,000 meters and 1.25 at 2,400 meters.

Haplotypes II, XV, and XVI showed the inverse relationship, with RIs of 1.28, 1.12, and 1.42, respectively, in the 1,400- to 1,600-meter range. All three saw their RIs decline in each subsequent distance category, all ending up well below 1.00.

"With the three-year-olds, there were clear cases where certain genetic types showed a clear leaning for stamina while others were associated with success at shorter distances," Harrison said. "Most of them show some kind of leaning, but not necessarily at this age group."

Although not covered in his recently published study, Harrison said he also has found correlations with some of the haplotypes' performances as two-year-olds.

For example, one group showed strong aptitude in short-distance two-year-old races but often failed to win much of anything at three. Another mtDNA type thrived in long-distance two-year-old races.

Thoroughbred Genetics also performed mtDNA studies for recent winners of a list of important stakes including the Japan Cup (Jpn-G1), Eclipse Stakes (Eng-G1), Queen Elizabeth II Stakes (Eng-G1), Prix de l'Arc de Triomphe (Fr-G1), Test Stakes (G1), Beverly Hills Handicap (G2), Matriarch Stakes (G1), Yellow Ribbon Stakes (G1), American Oaks (G1), Beverly D. Stakes (G1), Breeders' Cup Turf (G1), and the Melbourne Cup (Aus-G1).

Harrison concluded there is a true order of racing merit between haplotypes, based on distance.

"We would view mtDNA as the foundation of stamina ability," Harrison said. "You just cannot say mtDNA genes are the be all and end all, but we can say they are a component of stamina that needs to be taken into consideration."

Putting mtDNA theory to work

Thoroughbred Genetics has been operating commercially for about four years and using the new mtDNA analysis for about 18 months. Harrison said his company has been associated with two black-type winners already, although the first batch of about 50 or 60 horses the company was involved with are two-year-olds of 2006.

"This year is the main year where the two-year-olds will be put to the test. It's hard to know where they all are, but we should really be looking at who turns up at Royal Ascot," Harrison said. "Of course, we only advised on these horses. We didn't make the decisions, so we don't claim all the glory for it because the breeder has the final input. It's really a team thing."

Harrison declined to name any of his clients or their success stories, citing confidentiality agreements.

"I don't think we're indispensable yet, so to breach confidentiality wouldn't do us any good," Harrison said.

Thoroughbred Genetics's work is performed on a blood sample. The cost to analyze the mtDNA of one mare or a young horse would be $400 to $600, but Harrison prefers to form contractual relationships with his clients.

In mating decisions, Harrison believes in matching stamina with stamina and brilliance with brilliance. He compares breeding a horse to building a race car, with all the parts working toward one goal.

"If you have a Formula One chassis, the best thing to do is build a Formula One car," Harrison said. "One of the things we feel that Thoroughbred breeders fall down on is people use too much diversity in mixing different stamina groups together. We think breeding horses with specific stamina objectives in mind could be the way to go."

Harrison says his system could also help revive lines that have lost direction or run into performance dead ends.

"If you have a nice family that runs into a dead end, perhaps it started producing sprinters and then tailed off, this test could give you an idea of where the family is at and what directions it's going," Harrison said. "It's difficult to quantify just how much of a contribution mtDNA has on running ability, but there is obviously a significant contribution, which is very useful to us right now."

What the experts say

"It's good that he's come and said there's a scientific reason for all of this, but certainly the top breeders in the world are already doing a lot of the things he's talking about. Whether or not the connections between mtDNA and race performance exist, the findings are very unsurprising because for generations there have been female families who have always shown propensity to get superior individuals, even after generations of poor performance."

Sheri L. Pitzer photo

ROGERS

Byron Rogers, *director of stallion operations at Taylor Made Farm in Nicholasville, Kentucky*

"It's not surprising that there is a difference in mtDNA and the distance capacity of horses. It's an interesting study, and I would say genetics is starting to tackle some performance-related issues sooner than I expected. The study discovered what it discovered. I wouldn't dispute the facts, but there are lots of questions on the applications and how this piece of information could affect breeding decisions. In Europe you have a more distinct stratification of distances than in the States, where a horse that is a sprinter-miler can stretch out and win the Kentucky Derby (G1) early in the season. It would be interesting to quantify how much training makes a difference."

PORTER

Alan Porter, *international pedigree analyst*

"I can't say I'm convinced, but it is intriguing. When you look at certain female families, you can see these patterns. Whether it's following the mtDNA trail is totally debatable. I don't put as much emphasis on the tail-female line as this study would suggest. If you use the tail-female line to dictate the stamina of a horse, that puts you in a very specific niche. But if you have a five-furlong mare and you breed her to a Dynaformer, he will add as much stamina as the female line will add speed. I don't think the tail-female line dominates the aptitude. There are too many other factors, especially if you're dealing with a super dominant stallion."

Photo by Z

PETERS

Anne Peters, *director of stallion seasons and mating for Three Chimneys Farm in Midway, Kentucky*

Pete Denk is a Thoroughbred Times staff writer.